ILLUSTRATED
ELECTRICAL REVIEW
A Journal of Scientific and Electrical Progress.

VOL. 26. No. 10. WEEKLY.

NEW YORK, WEDNESDAY, MARCH 6, 1895.

$3 per Annum. Single Copies, 10 Cents.

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Entered at Post Office, New York, as Mail Matter of the Second Class.

VIEWS, NEWS AND INTERVIEWS.

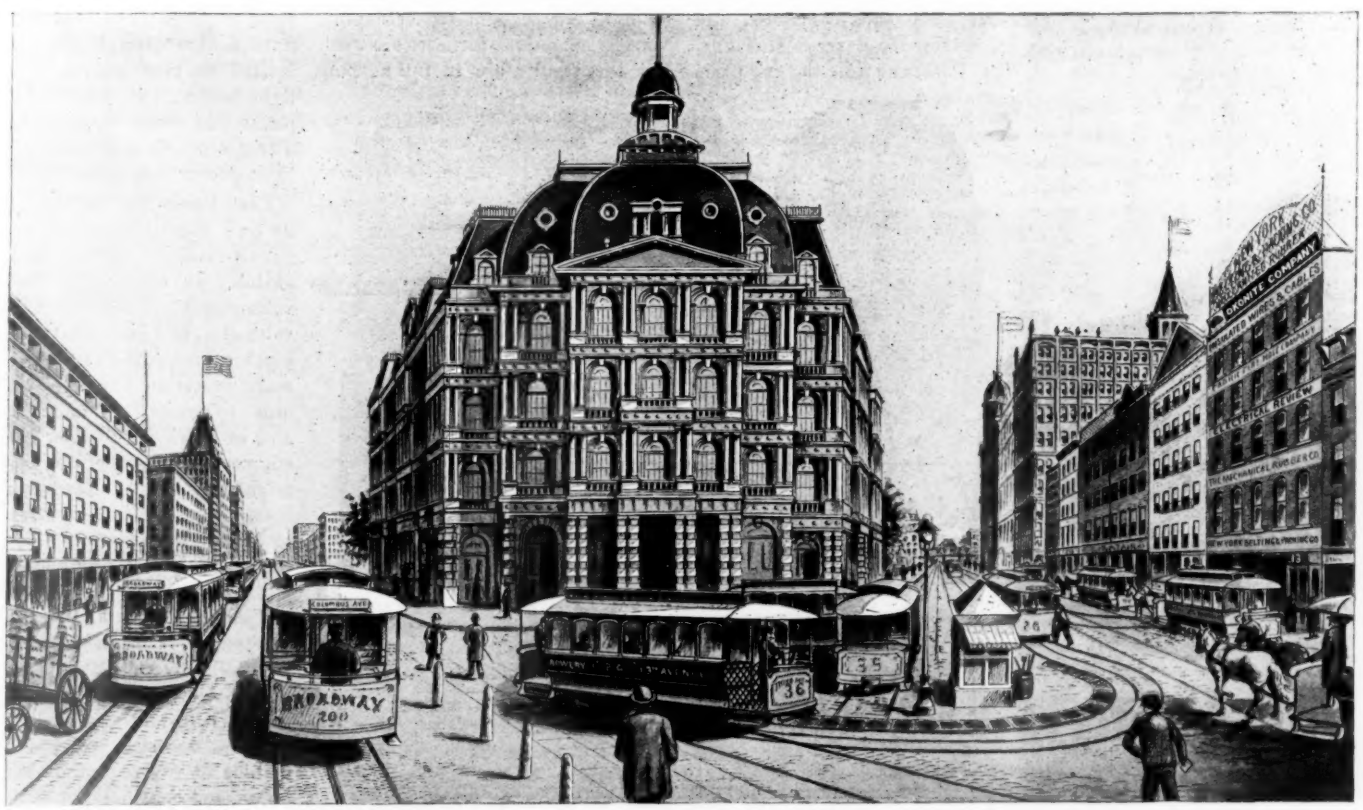
"It has occurred to me many times," observed Meekin, the lazy inventor, "that a lot of energy is wasted by people walking up and down stairs. Some five years ago the idea took such a hold upon me that I determined to utilize this stair energy, at least in my own house. I lived in a street in New York city where we had to use a force pump to fill a water tank in the top of the house so as to get sufficient pressure in the water mains. I finally decided to make my family, while ascending and descending the stairs, generate sufficient power to run a dynamo whose current would be used to operate an electric pump, which was to fill the water tank. I had the stairways remodeled so that the treads worked on a hinge, the front face of the treads being about two inches higher than ordinarily. Under each tread I placed heavy steel springs, which connected with another invention of mine—the Meekin power conservator. This apparatus was in harmony with the dynamo and the pump was connected with the latter in the usual manner. I connected up the whole scheme and then stood in the front hall while my wife came down stairs. The slanting steps were a little awkward at first and the springy sensation wasn't very agreeable, but anything goes in the interest of science. My wife got down all right and generated sufficient energy to start things going. The children didn't like the new steps and took to sliding down the baluster rail, which discommoded me slightly. In the end, I found that I would have to race up and down stairs about twice as much as usual to keep the old thing running. My friends, too, observed that I was gradually acquiring a walk like a horse with the 'string halt,' and I felt I was getting a little 'spring-kneed.' So I gave it up and paid a man 50 cents every other day to furnish the water with a hand-pump."

The library of the late Prof. Hermann von Helmholtz has been purchased by the German Government for the State Physico-Technical Institute in Berlin.

POST OFFICE SQUARE, NEW YORK.

THE BUSIEST SPOT IN THE METROPOLIS.

The illustration on this page shows Post Office Square, New York city, formed by the junction of Park Row with Broadway. It is the busiest spot in the metropolis.



A VIEW OF POST OFFICE SQUARE, THE BUSIEST SPOT IN NEW YORK CITY.—ASTOR HOUSE ON THE LEFT, POST OFFICE IN THE CENTER, AND "ELECTRICAL REVIEW" OFFICES ON THE RIGHT.

On the left of our illustration is that old and famous hostelry, the Astor House, once the most sumptuous hotel in the United States and still a profitable property. It faces Broadway and the cable cars pass its doors up and down town at intervals of 30 seconds. The sidewalk traffic at this point in Broadway is enormous during business hours. William Dean Howells once said,

"If you know anybody you will meet him on Broadway in New York city." If he's a business man, you will probably meet him near the Astor House.

In the center of the picture is the New York Post Office, an unlovely piece of government architecture, standing on what was once the lower end of City Hall Park. The building is totally inadequate to the needs of the city, and is surpassed in every sense by post office buildings in many smaller cities—notably that in Cincinnati.

The right hand side of the picture shows the lower end of Park Row, the paradise of newspaper men. The offices of the ELECTRICAL REVIEW at Number 13 are shown. Our windows face the heart of this busy scene. The noisy hum of the street, the clanging cable car gong and the rumble of heavy trucks are always with us. The Third avenue cable cars come down Park Row and make a swift curve around the Square, returning up the Row. This curve is a nice piece of engineering, and is exactly the shape of an incandescent lamp.

We would not be surprised at any time to learn that these two cable lines were to be changed over to underground electric systems.

That Welsbach Scare Waning.

An esteemed friend who takes a lively interest in electric lighting, writes us from Boston as follows:

"You did a good thing in publishing in your issue of January 30 the full text of the paper by Mr. Goetz on the Welsbach burner, read before the North Western Electrical Association. This matter of the Welsbach burner has caused not a little uneasiness among lighting companies, but I cannot yet believe that it is going to be much of an obstacle to the steadily increasing popularity of the incandescent lamp. I have mailed a copy of the number of the REVIEW containing Mr. Goetz's article to several customers who had expressed their uneasiness concerning the Welsbach burner, and I only wish that every central station manager who is so disturbed could read Mr. Goetz's paper."

THE POWER STATION OF THE COLUMBUS CENTRAL RAILWAY COMPANY.

A TYPE OF NOVEL AND MODERN CONSTRUCTION.

In the ELECTRICAL REVIEW for August 1, 1894, was published an illustration showing the exterior of the Columbus Central Railway Company's new power-house at Columbus, O., together with a brief description of the proposed plant. The installation has since been completed, and we are indebted to Barry & McTighe, of New York, who were the engineers in charge of construction, for the following additional details:

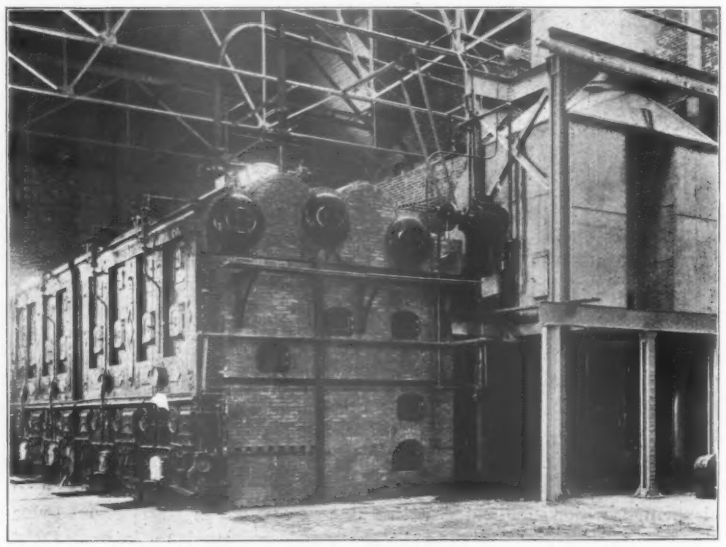


FIG. 1.—INTERIOR VIEW OF BOILER ROOM, COLUMBUS CENTRAL RAILWAY COMPANY.

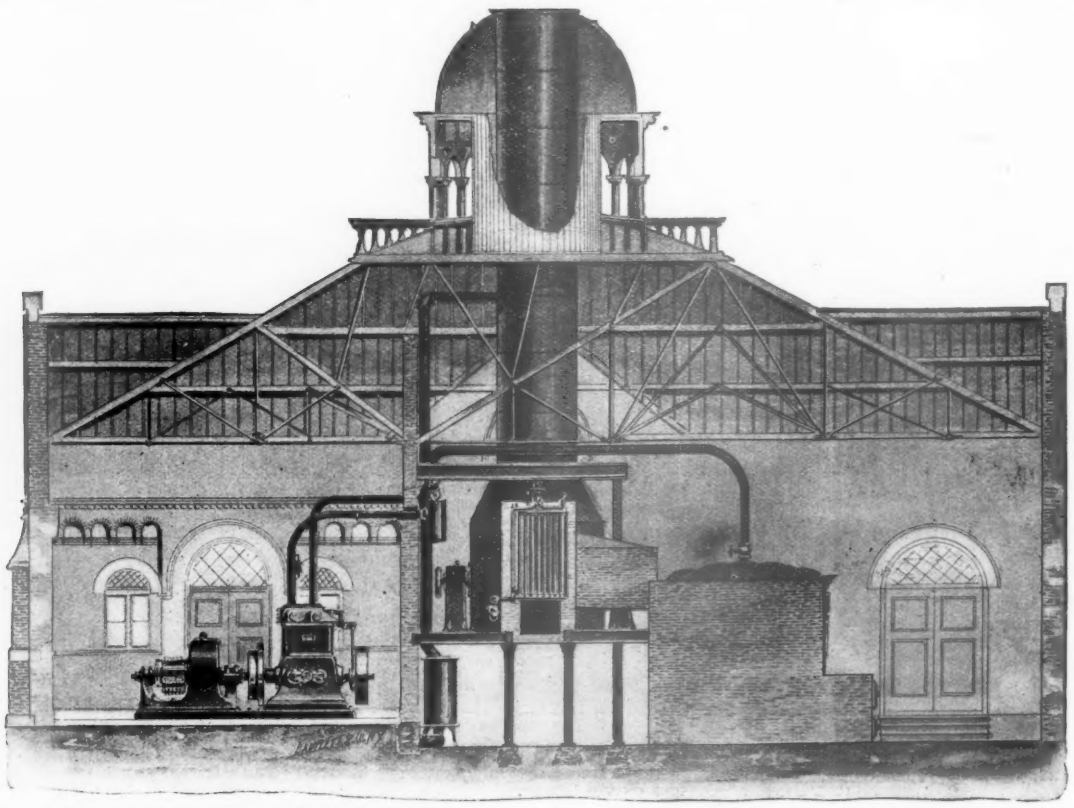


FIG. 2.—SECTIONAL VIEW OF POWER STATION, SHOWING CONCEALED SMOKE STACK, COLUMBUS CENTRAL RAILWAY COMPANY.

Referring to the illustrations, Fig. 1 is an interior view of the boiler room, Fig. 2 is a section through the station showing the ingeniously concealed smokestack, Fig. 3 is a view of the switchboard and Fig. 4 shows the interior of the engine and generator room.

The boiler plant consists of four "Class A" Stirling boilers, each guaranteed to be 200 horse-power on the centennial rating of 30 pounds of water per horse-power. With compound engines and economizers three boilers are abundant for the load of the two 500 horse-power engines now installed, and space is left in the boiler room for four more boilers of similar size to be installed before 1896. The boilers are arranged in batteries of two, each battery having its own independent stoker engine. Murphy smokeless furnaces are used, and the results are in full keeping with the name, for the plant is really smokeless, notwithstanding the unfavorable condition of light load.

There will be ultimately four engines and generators, two of which are now installed. Each of these units is a Westinghouse compound, running non-condensing, with cylinder dimensions of 18 and 30 inches diameter by 16 inches stroke, direct connected to a 200-kilowatt Westinghouse multipolar generator. Each unit is mounted on a heavy cast-iron base, and an insulated universal spring coupling is used between the engine and generator.

The switchboard is probably a step in advance of anything yet made in this line. The instruments are all mounted on dark marbleized slate, there being four generator panels, one main station panel and panels for 16 feeders. The slate is extra heavy, being one and one-half inches thick, marbleized in front and heavily shellaced on the back. As shown in the illustration, the panels are set in a massive framing of solid carved and polished mahogany. The carving and ornamentation are very artistic. The board over all is 31 feet long by 10 feet six inches high, and is three feet six inches clear from the wall. All wires and cables from the generators are laid in conduits under the concrete floor and pass into a pit behind the switchboard, which is provided at floor line with removable hard wood gratings. This allows the ordinary use of a floor behind the board, while affording instant access to any part of the pit. All positive bars and wires behind the board are painted red and plainly stenciled "Positive—danger." Equalizer connections and bars are green and negatives are black, and all plainly stenciled in large white letters. A few incandescent lamps are properly located to give abundant working light behind the board and in the pit, in case such is necessary at night. Three windows make the space very light during the day.

Each feeder line on the board has its own special ammeter, automatic circuit-breaker and quick-break switch. In addition to the station voltmeter, there is a Bristol recording voltmeter, and later on there will be a general recording ammeter. Automatic operation has been the aim, in order to reduce the number of attendants as much as possible. With one engineer in the generator room, who might be called momentarily into the boiler room, it was deemed expedient to install an automatic alarm. So each of the automatic circuit-breakers is fitted with suitable contacts controlling the circuit of a large and substantial vibrating bell located in the boiler room. Should an automatic "blow," the circuit of the gong is instantly closed, and an alarm is sounded which is plainly audible at every part of the power house, and continues to sound until the automatic circuit-breaker is attended to. This novelty proves very effective.

The lighting, at night, of the switchboard, generator room, engines, boilers, pumps, etc., and car house, pits and washroom, is all done by a small direct-coupled 110-volt machine and standard engine. This is especially advantageous late at night, after the last car is in, as it allows a complete shutting down of the large engines and generators for inspection throughout, while affording plenty of light for this very purpose, as well as the necessary light in boiler room and

car house. At the same time this late night lighting costs but little, as by it steam is utilized which would otherwise be largely wasted. The idea seems to be good.

In the engine room, on a level above the brick corbling on the walls, is arranged an eight-ton traveling crane, carrying an operating platform from which all the crane's movements are controlled. The crane is capable of handling the heaviest piece in the engine room. It gives great satisfaction to the attendants.

The car house is a steel-trussed structure resting on steel columns built into and forming part of the side walls, which are of brick. The clear span includes eight tracks, being 88 feet, so that the entire space of the car house is unobstructed in any way. A departure has been made in the front. Though the trolley wires are 18 feet from the floor, the doors are but 13 feet high. The front is constructed with slots 6 feet high and one foot wide, near the top of which the trolley wires are supported. Each slot has double swinging doors of hard wood, but light weight. These yield in both directions to the passage of the trolley pole and work admirably, while excluding snow and rain to perfection. The main doors are novel, too. The two extreme side doors swing on heavy wrought-iron hinges, bolted to the front columns of the building. The intervening six tracks are covered by six doors arranged in two sets of three each. In each set the middle door is very heavy, rides on three large wheels which track on a flat-grooved girder rail firmly fixed across the front and anchored with angle-plates to the track rails, while above, each of the heavy doors is provided with guard-rollers moving in a guid-way of channel iron held in position by the front truss and anchored back to the second truss. Each of these heavy doors has the two adjoining doors hinged to it, one at each edge, and the hinges are formed to permit both the swinging doors to be folded against its front. In this position two tracks are thrown open, and the middle track of the triple set is opened by rolling the whole to one ride. The construction is massive and strong, but though a triple door set weighs over 1,000 pounds, one man can easily roll it clear across the building. The utility and convenience of this construction is so manifest that it speaks for itself. The building is splendidly lighted in the day time, having all the ventilator windows and a large number of side and end lights.

The cars are conceded to be among the finest in the country. They are of the "Accelerator" type, with 20-foot bodies and four-foot platforms.

Pintsch gas lights, made by the Safety Car Heating and Lighting Company, of New York, are used in the cars. This is the first electric railway company in the country to adopt the gas system of car lighting, and the innovation is but one of many which Barry & McTighe have carried out in this highly instructive installation. Each car is equipped with Pintsch lamps, with four flames enclosed in heavy clear glass globes. The light is steady and mellow, and the eight burners consume less than six cubic feet of gas per hour.

ELECTRIC RAILWAY NOTES.

Officers of electric railway companies are requested to send promptly to the ELECTRICAL REVIEW *notices of meetings, election of officers, declarations of dividends, financial reports and all items of interest in connection with the financial and practical operation of their roads.*

The Lansing, Mich., Electric Railway Company's car barn and nine cars were burned on February 20. Loss, $20,000; probably covered by insurance.

The railroad committees of Wisconsin Legislature are hearing arguments on bills to compel street railways to adopt vestibule cars. Henry C. Payne appeared for Milwaukee and Manager Shuman for Racine. President Matson of the Street Railway Union was there in its favor, together with several other men. It is not thought that the bill will become a law.

Judge Speer, of the United States Court at Savannah, Ga., on March 1 ordered the receivers of the Electric Railway Company to advance fares from one cent to five cents, and also ordered two rival electric roads to show cause why they should not be required to advance their fares, on the ground that they had entered into a conspiracy to ruin the electric railway company by forcing fares down. One rival line has been selling two tickets for one cent.

The special Aldermanic Committee appointed to investigate the trolley system in Brooklyn, N. Y., handed in its report at a meeting of the board on February 25. The committee recommended that all cars shall be licensed, and that a placard stating that fact be posted in each car. Every accident shall be reported before noon of the next day. Speed shall be limited to eight miles an hour. Gates on the front platform shall be kept closed. Speed indicators, visible to all passengers, shall be placed on all cars. All cars shall come to a full stop at intersecting lines. Cars shall stop to take on or let off passengers at the first crossing.

Mr. W. G. Motley, F. R. G. S., a well-known mining engineer of Rat Portage, Canada, favored the ELECTRICAL REVIEW with a pleasant call recently.

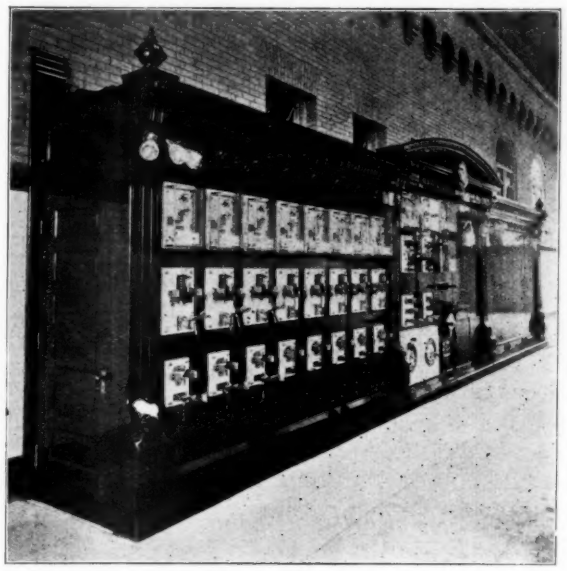


FIG. 3.—SWITCHBOARD IN COLUMBUS CENTRAL RAILWAY COMPANY'S POWER STATION.

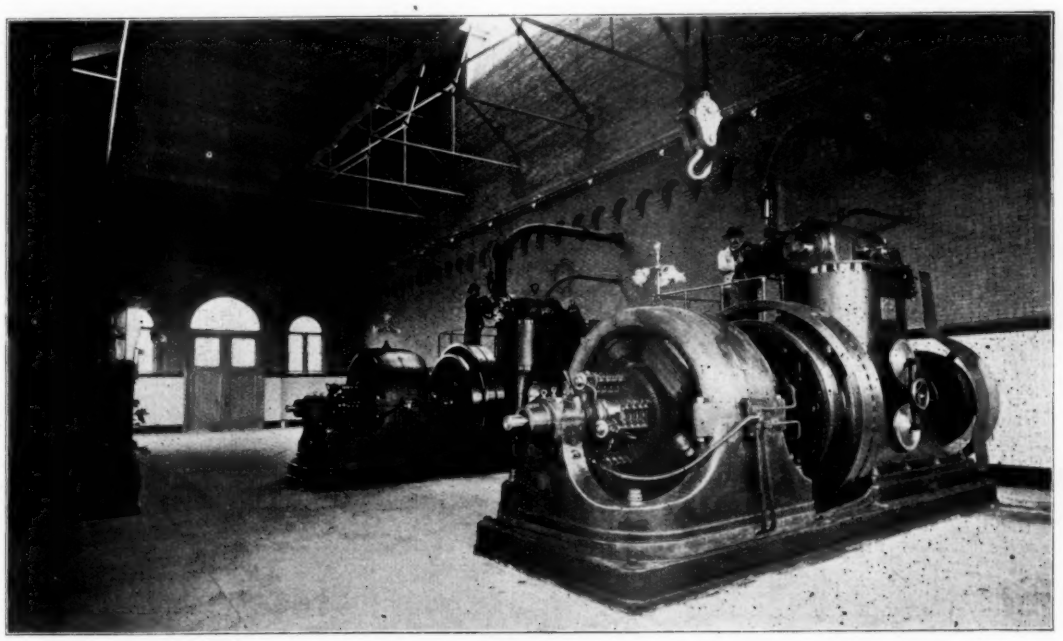


FIG. 4.—INTERIOR VIEW OF ENGINE AND GENERATOR ROOM, COLUMBUS CENTRAL RAILWAY COMPANY.

ELECTRIC LIGHT FLASHES.

The Galveston, Texas, Street Railway Company has been granted a franchise to engage in electric lighting.

The recent report that the Catholic University of America, at Washington, D. C., was to install a $50,000 electric light plant is erroneous. A small plant for which the contract has been let will be placed in a new building just erected by the university.

The New England Engineering Company, of Waterbury, Conn., of which Mr. A. M. Young is president, has just been awarded a contract to install a complete steam plant for the Stafford Springs Electric Light and Gas Company, of Stafford Springs, Conn.

In last week's issue of the ELECTRICAL REVIEW mention was made of the victory of Russell B. Harrison's Citizens' Electric Light and Power Company, of Terre Haute, Ind., over the Terre Haute Electric Light and Power Company. The latter company asked for an injunction of restraint against the former, which was denied by Judge Henry, who based his finding mainly upon the proposition that public rights are superior to private rights. Judge Henry has given considerable time to the study of electricity and consequently was unusually competent to decide the matter. The contest between the two companies was a hot one, and involved many new and interesting legal and electrical questions. In looking up decisions in other States the attorneys discovered many cases between railway companies and light companies, telephone companies and light companies, and railway companies and telephone companies, but very few cases between light companies, and none of them involving the questions in this case. President Harrison expects to have his plant running this week, although not complete in its details. It will be the largest and the only triple expansion direct connected arc light plant in the world.

The Edson Pressure Recording Gauge Adopted by the Italian Government.

As indicative of the progressive nature of foreign naval officials and their desire to avail themselves of meritorious appliances that will make the handling and operations of steam plants on ship, as well as on shore, an exact, rather than, as is too often the case, both at home and abroad, a doubtful quantity; and as a tribute to a standard American invention, long and favorably known to steam users throughout the world, the following report of a specially appointed Italian Naval Committee is of unusual interest.

The Italian Government is to be congratulated in having had the Edson pressure recording gauge brought to its attention, and for having so clearly recognized its value and efficiency as applicable to its requirements. The government has placed with the maker, Jarvis B. Edson, 87 Liberty street, New York, an initial order for 10 of the well-known No. 1 style recorders, some of which are to be used on ship board, others in the government shops, as indicated in the subjoined report of its committee:

REPORT OF SPECIALLY APPOINTED ITALIAN NAVAL COMMITTEE ON THE EDSON PRESSURE RECORDING AND ALARM GAUGE.

The undersigned committee charged with the trials at full speed of H. M. S. "Cristerfero Colombo," having received special orders No. 6467 from the commander-in-chief, under date of October 5, 1894, on the 9th and 13th insts., proceeded with the tests of the Edson pressure recording and alarm gauge, having caused the same to be attached to the steam apparatus of the ship.

The instrument was placed in connection with the boilers by a copper pipe of prescribed dimensions. Its height above the origin of the pipe was 2.40 metres, so that, owing to the weight of condensed steam, it was necessary to add 3.5 pounds to its dial indications to make them conform to the readings of the ordinary gauges.

This allowance having been made, the committee was enabled to judge of the exactness of the record that is clearly traced on the paper band or chart, regularly moved by clock train designed for the purpose.

Though the spaces representing time on the abscisses and those that measure the pressure on the ordinates are small, they are, however, sufficiently open to enable the varying pressures to be regularly and clearly traced.

The electrical alarm that was adjusted to ring when the pressure reached five pounds above the prescribed limit, 60 pounds, did not sound, the pressure at no time reaching this point.

The committee believes that the Edson pressure recording and alarm gauge entirely meets the requirements for which it is intended, when applied to steam boilers or any other apparatus containing a fluid under pressure; those requirements or claims being to enable an exact and durable record of all the varying degrees of pressure maintained during any stated time to be obtained.

As to the application of the said recorder, it is sure that it will be of unquestioned utility when applied to the propelling apparatus of H. M. S. ships, as it will at all times indicate both to the engineer and to the officer in command of the ship the operations of the boilers and render their control of them always absolute; to compare said operations with those of other ships, as well as to compare on the same ship the records obtained during the different watches, and in the event of abnormal indications to seek for the causes.

It is also satisfied that the continuous inspection of the records of the variations of pressure will be a stimulus for the exertion of best efforts on the part of all concerned to keep the same most constant, with the accruing advantages of economy, efficiency and safety.

The Edson recorder will be very useful in testing the engines for the determination of mean pressure, and also in all experiments that may be made with the boilers.

The Edson recorder, in addition to its great value on the men-of-war, can be most usefully applied to the boilers of stationary engines, the care of which is entrusted to one engineer alone, to enable the managers of shops, as well as the officers, to control and regulate their operation.

(Signed)—

A. MELANCINI,
First-Class Naval Engineer,
C. FERRARONI,
First-Class Chief Engineer,
G. RICCIO,
Principal Chief Engineer, Second-Class,
F. GAVOTTI,
Commander H. M. S. Ship, "Cristerfero Colombo,"
G. FARINA,
Captain-President,
Committee.

Venice, Italy, October 18, 1894.

FIG. 1.—STORAGE BATTERY INSTALLATION AT MERRILL, WIS.

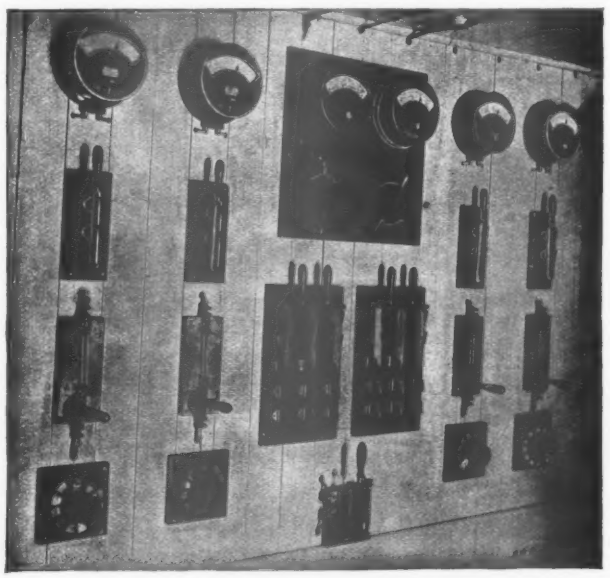


FIG. 2.—SWITCHBOARD FOR MERRILL, WIS., STORAGE BATTERY PLANT.

The Oldest Electrical Weekly In The United States.

[*From the Spokane, Wash., Miner and Electrician.*]

THE ELECTRICAL REVIEW has come off first best in its controversy with the *Electrical World* as to which was the first weekly paper to be published in this country devoted exclusively to electrical matters. They have proved that their first issue appeared March 22, 1883, more than five weeks before its rival. The margin is narrow but it is a clear one.

The Chicago City Council on February 25 passed two ordinances, one gas and one electric, by a vote of 28 to 22 in each instance. One ordinance gave a franchise to the Cosmopolitan Electric Company and the other to the Ogden Gas Company, each for 50 years. Both cover the entire city and confer unusual privileges. The maximum charges by the Cosmopolitan Electric Company were fixed at one cent an hour for 16 candle-power lights.

Storage Battery Plant for Electric Light and Railway Work at Merrill, Wis.

Merrill, with a population of about 9,000, is situated 352 miles northwest of Chicago, in the lumber regions of Wisconsin, on the Wisconsin River. The city is divided into two parts, the east side and the west side, by the Prairie River, which here flows into the Wisconsin. The Merrill Light and Railway Company furnishes all electric light in the city and operates the electric railway, connecting the east and west side.

The electric lighting of the city is divided between two stations, that on the east side being run from a water-power plant, and the west side from a steam-power plant. The railway generator is operated by a water-wheel at the east side station.

The east side plant contains two water wheels, one for lighting, the other for railway, which operate two 25-kilowatt Edison machines, run on the three-wire system; one United States machine (25 amperes, 500 volts), for series incandescent street lighting, and a Westinghouse railway generator of about 75 kilowatts capacity. The west side electrical equipment comprises a 20-kilowatt Edison, a United States machine (25 amperes, 500 volts), and a 30-light Thomson-Houston arc dynamo. The railway is one and three-quarter miles long, single track with two turn-outs. The road was built for three cars, but ordinarily only two are operated, with from 10 to 15 minutes' headway.

Some months ago the company was brought face to face with that problem, so frequently occuring in the electrical field, of the best plan for enlarging the power plant to meet the requirements of increasing demand. Having both water-power and cheap steam-power, the company were enabled to judge as to the relative economy of the two, and, naturally, found that the former yielded the best results in that respect, but the fact that the water-power was limited and at some distance from one of the two-light centers, introduced into the situation a further problem.

After much discussion of the question it was decided to install a storage battery plant in a sub-station, at or near the distant light center, the power-house being itself at one center.

It was decided that the battery should not only be utilized for increasing the light capacity, but also for regulating the voltage on the railway circuit, which was far from satisfactory, owing to the impossibility of obtaining a governor for the water-wheel, which would respond to the great fluctuations in railway demand. In fact, it had been determined that better results were obtained by running the wheel entirely without governor.

It was during the hours of heavy lighting, however, that the unsatisfactory operation was most manifest, when it became necessary to couple to the same shaft the wheel driving the lighting machines and that running the railway generator, in order

to obtain sufficient power for lighting. So limited was the power that only one car could be run during lighting hours, and even that in a feeble, uncertain way. Every fluctuation in railway demand caused a corresponding fluctuation in lighting circuit. A frequent fluctuation of as high as nine volts, on each side three-wire system, was recorded.

The storage battery plant recently installed is situated midway between east and west sides on line of trolley road, about three-quarters of a mile from east side power house and one-quarter of a mile from center of west side light distribution. The plant contains 240 eleven "F" Chloride accumulators, capacity 500-ampere hours at 50-ampere rate, manufactured by the Electric Storage Battery Company, of Philadelphia. The batteries are divided into four series of 60 cells each, connected to a switchboard, so arranged that cells may be connected to railway, 240 in series, or to lighting circuits, two parallel series of 60 cells each, on each side of three-wire system, capable of supplying normally 400 sixteen candle-power lamps for 10 hours, or, at maximum discharge, 600 lamps. An independent feeder connects battery with the east side power house, three-quarters of a mile distant. A variable resistance is placed in circuit between battery and railway, so that when battery is fully charged, requiring a voltage of 600, the voltage on railway may be cut down if necessary.

Fig. 1 was taken from a photograph showing battery as installed. The switchboard, with diagram of connections, is shown in Figs. 2 and 3.

The position of the blades in the two large double-throw three-point switches, in center of board, determines the connection of the battery, either to railway circuit (with 240 cells in series), as shown, or to three-wire lighting circuit (with two parallel series of 120 cells each), when in reverse position. The small rheostats on switchboard are used for equalizing the four series when discharging on lighting circuit. The two large rheostats (not shown) are placed in lighting circuit, one on each side of three-wire system, to regulate battery discharge on the line. By means of a double-throw, single blade knife switch (shown in diagram, Fig. 3, under right hand discharging rheostat) one of these rheostats can be cut into railway circuit and utilized for regulating battery discharge. By reference to diagram it will be seen that the feeder from power house generator is so connected to board, that generator may be disconnected from railway circuit without disturbing battery connection and *vice versa*. Thus, if generator fuse blows, the battery will run the railway without interruption; if for any cause the battery is disconnected, the generator will perform the work on railway. When discharging all in series the four ammeters read together; when in two parallel series, each ammeter gives discharge of the 60-cell series to which it is connected. The ammeters read both ways, indicating both charging and discharging current.

The right hand voltmeter (by means of four-point voltmeter switch) gives voltage of each of the four 60-cell series, while the left hand voltmeter gives voltage of the 240 cells in series, of the railway circuit and of each side of the three-wire system.

A switchboard at the power house containing voltmeter, ammeter, fuses, switches, field rheostat and automatic break, enables the dynamo tender to connect generator to railway direct, or to battery feeder, and to regulate current without any assistance at battery house. He can also determine, by reference to voltmeter, the condition of battery charge, and regulate charging current to best advantage. It is, therefore, unnecessary to have attendant at battery house, except when a change is made in battery connection from railway to lighting circuit, and *vice versa*, and when the requirements of service demand more or less resistance in circuit.

The charging is performed altogether by a railway generator during the period when cars are running and the battery is not required for lighting, the battery at same time regulating railway voltage and demand on generator.

On January 4, 1895, the battery was connected to railway circuit. The great improvement in running of cars was immediately noted by all, but it was at night that the contrast was most apparent. The two water wheels were connected together as usual, but the railway generator charged the battery at almost a steady rate, instead of running a car with its ever-varying demand of from 0 to 120 amperes. Instead of one dimly-lighted slow-running car, two brilliantly-lighted cars were operating at the highest speed allowable on the streets. Instead of a succession of sharp peaks, the voltage curve of lighting circuit became practically a straight line; instead of nine volts variation on each side of three-wire system, as at first, there was practically no variation, demonstrating most clearly the capability of battery to respond to all demands of railway, no matter how severe.

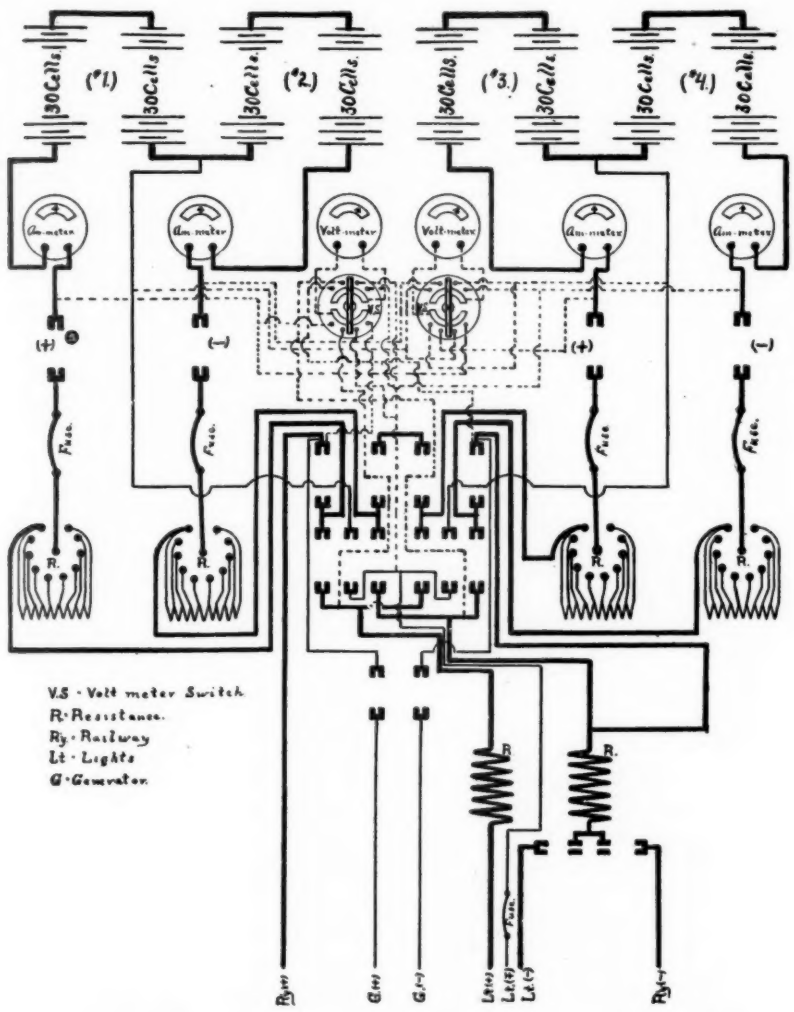


FIG. 3.—SWITCHBOARD CONNECTIONS FOR MERRILL, WIS., STORAGE BATTERY PLANT.

Benjamin Franklin's Statue.

[*From the Philadelphia Record.*]

A Summer and a Winter in an exposed position on the campus north of the University of Pennsylvania Library has severely tested the enduring qualities of the statue of Benjamin Franklin, which, during the World's Fair, graced the main entrance to the Electricity Building. The extremes of heat and cold have fractured the philosopher's right leg just above the ankle, the seams of his coat are burst open in the back and his neck is encircled by a narrow fissure. But the most severe trial of all for the author of "Poor Richard's Almanac" is that last Summer some children, in climbing up to get a better view of Franklin's face, broke his left arm near the shoulder, and now that limb is supported in a wire sling.

Electric Buoys in Gedney's Channel Replaced.

On the night of February 6, the heavy ice drifting seaward wrecked the electric lamps placed on the buoys marking Gedney channel in New York Bay, over the bar. As this channel is the most direct and deepest the large steamers prefer using it, and several of them have deferred entering till daylight on account of these lights being extinguished. They could have been repaired in a day, but the drift ice would have demolished them again. Now, however, the Lighthouse Department has placed new lamps on the buoys and the channel is again marked by the electric lights.

The New York State Militia In British Eyes.

The United States militiamen, according to a sketch in the New York ELECTRICAL REVIEW illustrating the strike of tramway employés in Brooklyn, very much resemble many of the French soldiers.—*London Electrical Engineer.*

For Puddin'heads.

[*From the New York Sun.*]

The "New Journalism," to which we have heretofore adverted as attaining a certain maturity in this town, partakes of the nature of swindling, pure and simple.

ELECTRICAL REVIEW

Published at 13 Park Row,
P. O. Box 2339. NEW YORK.

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REGISTERED CABLE ADDRESS:
"ELECTVIEW," NEW YORK.

1546 "CORTLANDT," TELEPHONE CALL.

SUBSCRIPTION TO THE
ELECTRICAL REVIEW.

One Year, United States and Canada, - $3.00
One Year, Foreign Countries, - - 5.00
Single Copy, - - - - - - - .10
Back Copies, each, - - - - - - .25

NEW YORK, MARCH 6, 1895.

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The incandescent lamp men are ready to fling out their banners on the outer walls.

Everybody, regardless of politics, will rejoice over the final adjournment this week of the present inefficient and imbecilic Congress. We expect better things of the new Congress.

THE BATE CASE.

At last a decision has been reached by the United States Supreme Court in the famous Bate refrigerator case, and it is against the life of the Edison incandescent lamp patent and the Edison telephone patents. In these two instances the electrical people devoted to electric lighting and telephony took great interest in the outcome of the case.

The decision had no doubt been discounted by the companies adversely affected, and it will be hailed with joy by all others.

The ELECTRICAL REVIEW is glad that the agony is over. There will undoubtedly be a renewed activity in the incandescent lamp and telephone branches of the electrical field.

Gen. Benjamin F. Tracy, when asked to act as counsel for the Metropolitan Telephone and Telegraph Company against the bill before the New York Legislature reducing telephone rentals, replied that he would accept if he could be convinced the company's charges were fair. The officials promptly granted the distinguished Ex-Secretary of the Navy the fullest opportunity for expert investigation, and he became in the end very enthusiastic, and presented the masterly argument that compelled the authors of the Gerst-Persons telephone bill to withdraw it from the Legislative Committee for repairs.

The annual dinner of the New York Press Club was held at Delmonico's, February 20, and was one of the most successful events in the history of the organization. It was the celebration of the twenty-first anniversary of the life of the club. President Jos. Howard, Jr., was the presiding genius of the occasion, and nearly 300 newspaper men and their friends were present.

An unusual demand for telephone equipment seems to exist in all parts of the country. Electrical supply dealers and contractors are doing a considerable business in installing private lines and interior systems. Judging from the inquiries on the subject received by the ELECTRICAL REVIEW there is lots of new business in this line for everybody who can handle it.

If you are not a regular reader of the ELECTRICAL REVIEW try it one year, and commence *now*. The interesting developments in the electrical field are reliably chronicled by this journal week by week.

WALL STREET AND THE ELECTRICAL STOCK MARKET.

The stock market during the period under review was weak until the latter day upon fears of further gold exports, which induced London selling, local bear transactions and some selling of long investment stock. On Thursday when it became certain that the bond syndicate would redeem its promises to prevent gold exports by selling exchange, and on the following day when it attempted to make money more attractive here than in Europe by sharply advancing call money rates, a general revival of confidence set in. It was reflected in a covering of short contracts and imparted to the market not a little strength. Bonds of all classes were stronger as a consequence of the sharp advance in the purchase price of the new Government 4's. The adjournment of Congress Monday will give the business of the country a chance to rally by virtue of its inherent vitality.

The course of General Electric during the week was downward. General bearish market conditions were in a measure responsible for its early weakness. Later it was subjected to a sharp bear attack, which broke the price from 29⅛ to 27, the lowest price ever recorded. This sharp downward movement caused a number of dissatisfied holders to let go. There were afloat the usual vague rumors of pending trouble. It is evident that the pessimistic regarding this company is not universal, judging from the following, which appeared in the Boston *News Bureau:* "The General Electric Company is now earning upon the basis of about $2,500,000 net per annum, and if orders, as they have come in for the past two months, continue well into the present fiscal year, which began February 1, there needs be no action as respects the impairment of the capital of the company, for the concern will earn itself into sound position. The company is doing the largest business in its history as respects the volume of its output measured in tonnage or pieces of machinery. Even with prices on the present low basis the cost sheets have been liberally reduced by the introduction of machinery and labor saving devices. The company has probably earned the past year above $1,500,000, but it has continued to charge off with a liberal hand and will shrink its assets still further in the fiscal accounting, so that probably very little margin of earnings above what may be necessary will be shown, and the capital account, which is now all a matter of bookkeeping, may be still further written down, swelling the capital deficit of last year. But the foundation will be laid for the business of 1895 and the exhibit next year, if times are even as good as at present, should give stockholders encouragement."

That concern usually has good information and very seldom places itself on record with a statement so positive. From this it is concluded that it knows whereof it speaks.

The Edison Electric Illuminating

Company of New York was firm and quiet at 99. The 1st five per cent debenture bonds sold at 107½ to 108. The company advertises that the interest due on these bonds March 1 will be paid by the New York Guaranty and Indemnity Company.

It is rare indeed in these days that a first-class bond of an electrical company is offered in the open market. Such a tender is made this week by E. C. Jones & Company. It is of $265,000 1st mortgage 6 per cent bonds of the Schuylkill Electric Railway, of Pottsville, Pa., at 103 and accrued interest. The whole issue is $500,000. The balance has been sold.

The Postal Telegraph Company re-elected its old directors at a meeting held this week. The annual reports show that 1,514 miles of pole line and 6,888 miles of wire were constructed during the year. Among the important lines was a second route to the Pacific coast, via Colorado, New Mexico, Arizona and California, consisting of two copper wires, 300 pounds to the mile. The stock was bid 60 with no recorded transactions.

On the Boston Exchange, Bell Telephone was steady at 193½; Erie Telephone was strong around 48½ to 49; General Electric preferred was weaker on the knowledge that there is little prospect for a resumption of dividends for a long time to come; New England Telephone was steady at 67½; Westinghouse common was bid 30½ and held at 31½; the preferred was bid 49½ and asked 50.

The Bell Telephone gross output in the month ending February 20 increased 5,918, the telephones returned increased 974, net output increased 4,944. From December 20 to February 20 the net output was 5,350, an increase of 8,865.

Of the inactive stocks the following prices were recorded: American Telegraph and Cable, 90; Commercial Cable, 130; Interior Conduit and Insulating was not quoted. It sold in February at 41⅛.

"BAIN."

New York, March 2, 1895.

Francis R. Upton Makes an Assignment.

Francis R. Upton, of Orange, N. J., well known in the electrical field and prominently connected with the Edison interests for many years, made an assignment last Saturday. The assignees are William J. Hammer, of Elizabeth, N. J., and John F. Randolph, of West Orange. Mr. Upton, according to the papers filed, is not now engaged in any business. His assets include promissory notes amounting to $20,000, real estate, and stock in various concerns. The value of the whole is not stated. The contingent liabilities, all to banks, amount to $52,750. Other creditors are C. B. Farley, $5,000; Woodstock National Bank, $5,000; South National Bank, $5,250; Standard Thermometer Company, $565; City of Orange, $1,000; German National Bank of Newark, $2,500.

Who is the "Chas. *H.* Brush" spoken of by the *Wounded Bird?* The constant changes in the staff of that publication evidently prevent much acquaintance with the names of distinguished electricians.

Pintsch Gas in Columbus Central Railway Company's Cars.

TO THE EDITOR OF ELECTRICAL REVIEW:

The bold innovation of substituting gas for electricity in lighting trolley cars was conceived and carried out by Barry & McTighe, the well-known engineers of 47 Cedar street, New York city, who have charge of the construction of this very complete system of railway, which is the first electric railway to use gas for lighting.

It was argued that electric light is not and cannot be made satisfactory so long as potential fluctuates, trolley-poles fly the wire and automatic circuit breakers "blow," not to mention the minor but frequent annoyances of lamp filaments and fuses giving out at critical moments. It was believed, too, that the cost in the long run for gas would be no greater, if not really less, than for electricity, while the light obtained would of course be abundant and steady.

The predictions of the above-mentioned firm have been more than fulfilled, and everyone is delighted with the results obtained in the cars of the Columbus Central Railway. Patrons of the gas-lighted cars are loud in praise of the improvement, comparison being very convenient as the cars of the Columbus Street Railway Company (the "Consolidated") are lighted in the usual fashion by incandescent lamps from the trolley wire.

The cars are large accelerators, made by Brownell in his best style, solid mahogany inside, with white and gold ceilings. The bodies are 20 feet long in the clear inside, and each car has two four-flame Pintsch lamps with heavy clear glass globes similar in style to those in Broadway cable cars. The light is abundant, and even with passengers standing and holding by the straps, the seated passenger can read his newspaper in perfect comfort at all times. The light never flickers, never loses its candle-power and is soft and mellow, yet brilliant, and its diffusion is greatly aided by the pure white ceilings, from which advertising cards are rigidly excluded.

The total consumption of gas by the eight burners is less than six cubic feet per hour.

A car carries two gas tanks, each 12½ inches diameter and five feet six inches long, a capacity of 10 cubic feet per car, which, when charged to 12 atmospheres, amounts to a total storage of about 120 cubic feet of gas, which is very rich and of extraordinary illuminating power. As the eight flames consume altogether but six feet per hour, and the midwinter lighting is about 10 hours out of the 24, it would be possible to charge but once in two days, but it is found best to charge regularly every day, the operation taking but a minute for each car.

After manufacture and compression to about 200 pounds per square inch, the gas is kept in a steel storeholder, from which a pipe line runs to different points in the car house, where charging valves are located and flexible hose used to reach any car as it stands.

The gas is made from a distillate intermediate between crude petroleum and kerosene, costing from 3¼ to 5 cents per gallon, according to location and transportation facilities. Coke is preferred as fuel under the retorts. One day-man and one night-man can readily make enough gas for 100 cars regularly operating.

The gas costs less than $1.50 per thousand feet, including everything; and as eight hours' lighting would be a very liberal average per day for every car throughout the year, the average consumption of gas per day per car may be safely estimated at 50 cubic feet, which, at $1.50 per thousand, would be 7½ cents per day per car for light, or $27.37 per year.

In comparison, electric light is dearer. For a similar number of lights the consumption of lamps from all causes would be about eight sets per year, or 64 lamps, which, at 35 cents each, would cost $22.40. Current used at rate of 60 watts per lamp (including loss in line) would be 480 watts, or .643 electric horse-power, or, say .8 indicated horse-power of steam-power, which is not usually produced at less than $25 per horse-power per year, or $20.00 per car per year. These two items make the total cost of electric light about $42.40 per car per year. Thus it would seem that the electric lights cost about 54 per cent more to maintain than the Pintsch lights. If this be true then the saving to be effected on a 50-car road would more than pay the interest on the cost of gas plant and equipments incurred in substituting gas for electricity.

M. G.

Columbus, O., March 1, 1895.

American Institute of Electrical Engineers.

At the regular monthly meeting of the council held February 27 it was voted that the general meeting of the Institute be held at Niagara Falls, N. Y., beginning on June 18. It is proposed to devote this meeting principally to the question of power transmission.

At the above mentioned regular meeting 11 associate members were elected and five associates were transferred to full membership.

At the meeting of the Institute held at 12 West Thirty-first street in the evening, Mr. H. Ward Leonard presented a paper entitled "Notes on Recent Electrical Engineering Developments in France and England." The paper was discussed by Messrs. Townsend Wolcott, J. W. Lieb, Jr., C. E. Emery, Herbert Lloyd, A. E. Kennelly, Wm. Maver, Jr., M. W. Forney, Cary T. Hutchinson, Richard Fleming, Joseph Sachs, Profs. F. B. Crocker and E. J. Houston.

Mr. William B. Vansize, who is thoroughly well informed on electrical patents, has recently opened enlarged offices in the Postal Building, 253 Broadway. Mr. Vansize is a competent and reliable patent attorney, and his many friends, among them the ELECTRICAL REVIEW, are pleased to note this evidence of improvement in business.

AFTERMATH OF THE CLEVELAND ELECTRIC LIGHT CONVENTION.

FLOTSAM AND JETSAM FROM ALL QUARTERS.

Mr. Partridge, of the Partridge Carbon Company, of Sandusky, O., was right at home in Cleveland, where he used to live.

The Mather Electric Company, of Manchester, Conn., was present in the person of its western representative, J. Holt Gates, of Chicago.

Mr. James F. Kelly, "that famous old-timer," was there for the New York Insulated Wire Company, and made his stand for "Grimshaw."

President M. J. Francisco presented to the ladies attending the Cleveland Convention a neat little sterling silver souvenir in the form of a medallion.

The Eureka Compound Company, of Sioux Falls, S. D., distributed samples of their commutator compound, which is put up in convenient stick form.

Genial Fred. Gilbert, of Boston, was on hand, and was kept busy with Messrs. Phipps and Huntley entertaining numerous friends in their swell suite at the Hollenden.

Mr. C. H. McIntire represented his company, the C. McIntire Company, of Newark, N. J., whose pure copper connectors and terminals are as popular as they are efficient and ingenious.

Kerite wires and cables were represented by Mr. S. F. B. Morse, of Chicago, the western agent for these standard products. The absence of Messrs. Brixey and Ham was much regretted by their many friends.

The advertising hit of the convention was the Okonite company's page advertisement in the ELECTRICAL REVIEW. The jumbled effect of a page full of the company's well-known trade-marks instantly caught the eye—and the trick was done.

Mr. L. H. Rogers, assistant general manager of the Brush Electric Company, was ubiquitous and had the advantages of Brush apparatus at his tongue's end. Mr. Rogers' especial hobby at the present time is the direct coupled Brush 125-light arc dynamo.

Mr. C. N. Black's interesting paper on "Large Arc Dynamos," read at the Cleveland meeting, will be found in this issue of the ELECTRICAL REVIEW. The new 125-light Brush arc machine which Mr. Black refers to is a distinct commercial advance on the part of the Brush Electric Company.

The Stirling company, makers of the well-known and popular Stirling water tube boilers, were ably represented by these gentlemen: Treasurer E. R. Stettinius; F. E. Bruce, of the Cleveland office; F. M. Faber, of the Pittsburgh office; M. J. Wehley, of the Toledo office, and Superintendent H. S. Pell.

THE MONOCYCLIC SYSTEM.

Read Before the National Electric Light Association, Cleveland, February, 1895, by Dr. Louis Bell.

DISCUSSED BY MESSRS. KELLY, THOMSON, SCOTT AND THE AUTHOR.

To the central station man no recent change in engineering practice can have more interest than the renaissance of alternating current work which is now in progress. Truth to tell, until quite recently the alternating current was somewhat under a cloud in the estimation of both station managers and engineers. It had served an immensely useful purpose in the extension of electric lighting to places where it would have been utterly impracticable to install a direct current system of any sort, on account of the scattered nature of the work. A very large number of stations have been installed on the alternating system, and I am sorry to say that a large proportion of them have been somewhat unsatisfactory, not in their general operation, but in the character of their service and the commercial results. It is quite common to find alternating stations with a plant efficiency considerably below 50 per cent, and in which the regulation is maintained only within, perhaps, about 10 per cent. Under these circumstances it is small wonder that the advocates of the direct current, the uses of which as an engineering problem have been very completely worked out, have been often somewhat violent in their animadversions on alternating currents in general. Nevertheless, in the last two or three years there has been a vast change for the better in alternating practice, a change not yet rapid, but bidding fair to be far-reaching. This change has taken up a three-fold path toward progress:

First, the use of large transformers is becoming more frequent.

Next, these transformers are more and more used in conjunction with systems of secondary mains; and, finally, it is now possible to install an alternating plant that shall be able to operate motors as successfully as can be done with direct current. In ordinary central station practice the motor service does not usually play a very important part; nevertheless, the ability to run motors is most valuable. It is more profitable, speaking broadly, to sell current for light, for a better price per kilowatt hour can be obtained; at the same time, if motors can be readily furnished, a useful day load can be obtained when it is needed, and the plant becomes the greater service to the community, a thing which, in these days of more or less friction with common councils, is of no small importance. Not only can motors now be successfully worked off alternating circuits, but off a wide variety of such circuits. As yet, however, there is no successful motor for use on the simple alternating system which has, for the most part, been installed in this country. While it is possible to construct a single phase motor even for 120 to 130 cycles per second, the frequency most used in America, it is at present very doubtful whether such a motor can be made to start and run in a way which will be generally satisfactory. Abroad, where low periodicities are used, better results may be obtained, but, even there, there is a noticeable silence on several important points in describing alternating motor practice. Appearances indicate that even with the advantage of low frequency motors for use on simple alternating circuits still start badly, and particularly require enormous currents at the moment of starting; hence the growth of various modified alternating systems, of which the polyphase is the best known, by the use of which it becomes possible to avoid this difficulty entirely and to work alternating current motors in every respect as satisfactory as those operated by direct current.

The polyphase motor has solved the problem of securing good motor service with alternating currents in a very complete manner, although at the cost of slight complications, which, while generally overestimated, are nevertheless distasteful to central station men, especially where the use of such a system would involve an extensive and costly rearrangement of the distribution service. It is the purpose of this paper to call your attention to the various methods of central station distribution, involving motor service on the alternating current system, and more especially to a modified single phase alternating system, which lends itself very readily to a very simple and straightforward distribution for lighting, without sacrificing the excellent motor service, which makes the true polyphase systems so desirable. For all around central station work the lighting service is of most fundamental importance, and convenience and economy in this particular must, in a vast majority of cases, be the first consideration. Let me invite your attention to this chart, which shows in a diagrammatic manner the general arrangement of various alternating circuits, including those already familiar and the polyphase and monocyclic systems.

First in order, both of time and extended use, comes the simple alternating system, single phase, with an ordinary two-wire distributing circuit. In operating the secondaries of such a system, we run immediately into limitations imposed by the feasible voltage for lamps, limitations which have acted as a brake on alternating current work and which are responsible for a good many difficulties in the operation of alternating plants. Opposite the diagram of this circuit I have placed the relative amount of copper required for lighting with such a distribution.

Next comes the alternating circuit modified for Edison three-wire distribution, which is so familiar in its character that it needs no description here. The amount of copper needed, on the supposition that neutral is half the size of either of the others, is, of course, enormously reduced, amounting, as you see, to less than one-third of that needed with the two-wire system; consequently, the secondary main distribution, so important to economical operation, can be carried out with the greatest facility. We are justified at present in saying that neither of these systems lends themselves to the ready operation of motors.

We may next consider the two phase alternating system worked with four wires, giving, if desired, two separate circuits for each machine. The copper here required is the same as that used with the single phase, and so long as the four wires are kept together motors can be freely operated. Here is assuredly a step in advance. The operation of two separate circuits, however, from a single machine, involves certain complications. In the first place, unless these circuits are balanced as to load, the operation of the system is somewhat difficult to make satisfactory in point of regulation. The circuits themselves have absolutely no influence on each other, but they are derived from the same machine, and with a given excitation of that machine, unless the loss in the two circuits is the same, the voltages must necessarily be different, consequently the generator cannot be compounded for both circuits unless the circuits are balanced. There are three ways out of this difficulty; none of them, unfortunately, are altogether unobjectionable.

In the first place, one can make the loss on the line so small that the difference in voltage due to any reasonable difference in load is of no moment. This can sometimes successfully be done, but more often it involves a very unnecessary cost for copper, and even at its best is likely to give regulation which, although better than that found on most simple alternating systems, is yet not good enough to suit the requirements of the best modern engineering.

Second, the machine can be compounded for loss on one of the lines, a feeder regulator being used on the other. This practically means hand regulation of one circuit.

Or, finally, both circuits can be operated by such regulators. In any case, if motors are to be operated, the two phases must be interlinked at least by one wire.

A somewhat simpler two phase distribution is that shown in the next diagram, where the two phases unite into a common three-wire circuit. The amount of copper here required differs very materially, according to the limitations of voltage that one chooses to fix. If the maximum voltage of the system is limited to the same maximum voltage used on the single phase two-wire or two phase four-wire system, the amount of copper required is very largely increased by the use of the third wire, owing to the fact that the two circuits combined are out of phase with each other by 90 degrees. The relative amount of copper required here is, as you see, 145.5. If, on the other hand, the question of maximum voltage between wires is neglected and the voltage is determined by the use of lamps of the same voltages as on the other systems, then the amount of copper is materially reduced, being a trifle less than three-fourths of that required on the systems before mentioned. In this case, we neglect the fact of there being an excessive voltage between the outside wires, and connect lamps between the middle wire and the two outside ones, much in the manner of an Edison three-wire system, with the exception, of course, that the saving in copper is not anything like the same amount. Such a system allows the distribution of the whole load for lights and power in a single circuit containing only three wires. It therefore avoids the difficulty of regulating two separate circuits. On the other hand, it causes a new and very curious difficulty, owing to the fact that the two combined phases are unsymmetrical with regard to the inductance of the system. The voltages between the middle wire and the two outside wires are unequal, when the systems are equally loaded, by an amount depending on the inductive loss on the line. Consequently, when in balance for regulation, the system is unbalanced as regards the load on the two sides, a condition which, although it may not lead to trouble in some cases, is still a menace to the successful operation of the system, unless the distribution be skillfully engineered. There is, however, the possibility of a noticeable saving in copper.

We may next pass to the three phase alternating system. The system which corresponds to the two phase four-wire system I pass by, as the use of three separate circuits would be even more troublesome than that of two, and would have no compensating advantages. The ordinary three phase circuit is that shown in the figure wherein the three phases are united into three wires and taken everywhere where the motors and lights are wanted. In this case, for the same voltage between wires, the amount of copper demanded is just three-fourths of that demanded for a single phase two-wire or two phase four-wire circuit. To compensate for this, there is the possibility of unequal voltages in case the three legs of the circuit are unequally loaded, owing to interaction in transformers and in the generator. So far as inductance on the line is concerned, the system is symmetrical and balanced.

If the load on the three branches is very unequal, as, for example, if one branch is entirely unloaded or very lightly loaded, while the other two are worked to their full capacity, there will be a perceptible unbalancing of the voltage. Experience, however, shows that with anything like the same care in balancing that would apply to an Edison three-wire system, this theoretical difficulty of balance is absolutely negligible. I say this advisedly, as the question has been so often raised that I have taken pains to investigate the conditions in three plants operating lights with reference to this particular thing, and the statement just made is the result of actual practice. It might be thought at first sight that good results could be obtained by combining with either a two phase or three phase system the Edison three-wire distribution. As a matter of fact, such a system would be unreasonably complicated with either two or three phases, as any central station man will readily appreciate, inasmuch as it would be necessary to have two or three-wire systems, each balanced, and mutually balanced with respect to each other, covering the territory if motors are to be run, or at least interlinked in a somewhat complicated way.

There is, however, a three phase system which does secure a very great advantage in copper. This is the three phase four-wire system shown in the figure. It consists of the ordinary three wires employed on the three phase system, with the addition of a balance wire proceeding from the common connection of the generator or the transformer and forming a part of the general distribution system. The lights are, as can be seen from the diagram, connected between either of the three phase wires and the balance wire. Between each of the outside wires there is, therefore, what may be considered two lamps in series, having, however, a phase difference of 120 degrees. The voltage of transmission, then, between each of the three main wires is 1.73 times the voltage employed in the lamp connected, nearly 200 volts for 110 volt lamps. This necessarily means a large saving in copper, which is still further enhanced by the fact that the three phase three-wire system requires intrinsically only 75 per cent of the copper used on the single phase or direct current system. The total result with this particular connection is but 29½ per cent of the copper required on the single phase system, supposing, as in the Edison three-wire distribution, the neutral wire to be half the size of either of the others. Such a system is in successful use at St. Hyacinthe, Canada, in connection with long secondary mains. The price paid for this saving in copper is the introduction of a fourth wire into the distributing system.

Comparing, then, the lighting distributions on the two and three phase systems, we find that if three wires only are used, both save very nearly the same amount of copper. The extreme voltage between wires on the two phase circuit is, however, considerably greater, and both are liable, but not likely, to become unbalanced.

There is this difference, however, that if we are to balance a three phase system in respect to voltage we need only to see that the load is equally distributed between the three branches. If we are to balance a two phase three-wire system, we must see that this load is unequally distributed between the three branches by an amount depending on the inductance of the line. We, therefore, see, comparing the polyphase with the single phase system, that the price we have to pay for the privilege of successfully operating motors is a certain amount of complication in circuits, which, while not of great importance in new installations, hinders the ready adaptation of a polyphase system in a plant having already a large number of circuits installed. Attractive as the single phase is in its beautiful simplicity of wiring, we cannot yet successfully run motors from it. It was for the purpose of preserving that simplicity of distribution which is peculiarly valuable in connection with large central stations, especially those already installed, and joining to this the same ability of running motors found on the polyphase system, that the monocyclic system, to which I am about to call your attention, has been perfected. You see it first in its two-wire form. Here, so far as the lighting distribution is concerned, it is absolutely identical with any of the alternating systems now installed in simplicity, convenience and in the amount of copper necessary. The main circuit of the monocyclic machine constitutes a simple, single phase alternator, and, so far as the lighting on the system is concerned, is identical with it, connected in precisely the same way, feeding, if desirable, into the same circuits without change. There is, however, on the armature of the monocyclic machine, a supplemental coil, shown on the diagram as connected to the middle point of the main winding on the monocyclic machine, from which a power wire may be be led. This need be of but small cross section, and only has to be carried to those points in the system at which it is desired to operate motors, and, as I shall presently show, this power wire enables one to run motors possessing the same desirable characteristics as the polyphase motors, and, indeed, generally identical with them, without in any way distributing the lighting distribution, except in so far as Ohm's law is a necessary limitation on all combined power and lighting circuits. In the last diagram here, we see the same device applied to an Edison three-wire system for the distribution of lights, along with which is carried the same insignificant power wire, which permits the successful operation of motors. The value of the three-wire feature in the distribution of lights is evident, the amount of copper being the same as in an Edison system of the same voltage. With this monocyclic system we can compound the generators for any reasonable loss in the line, and can arrange the lighting system without incurring any troublesome questions of balance, so as to give as good regulation even as can be obtained on a direct current system. Beyond this we have the power of running motors.

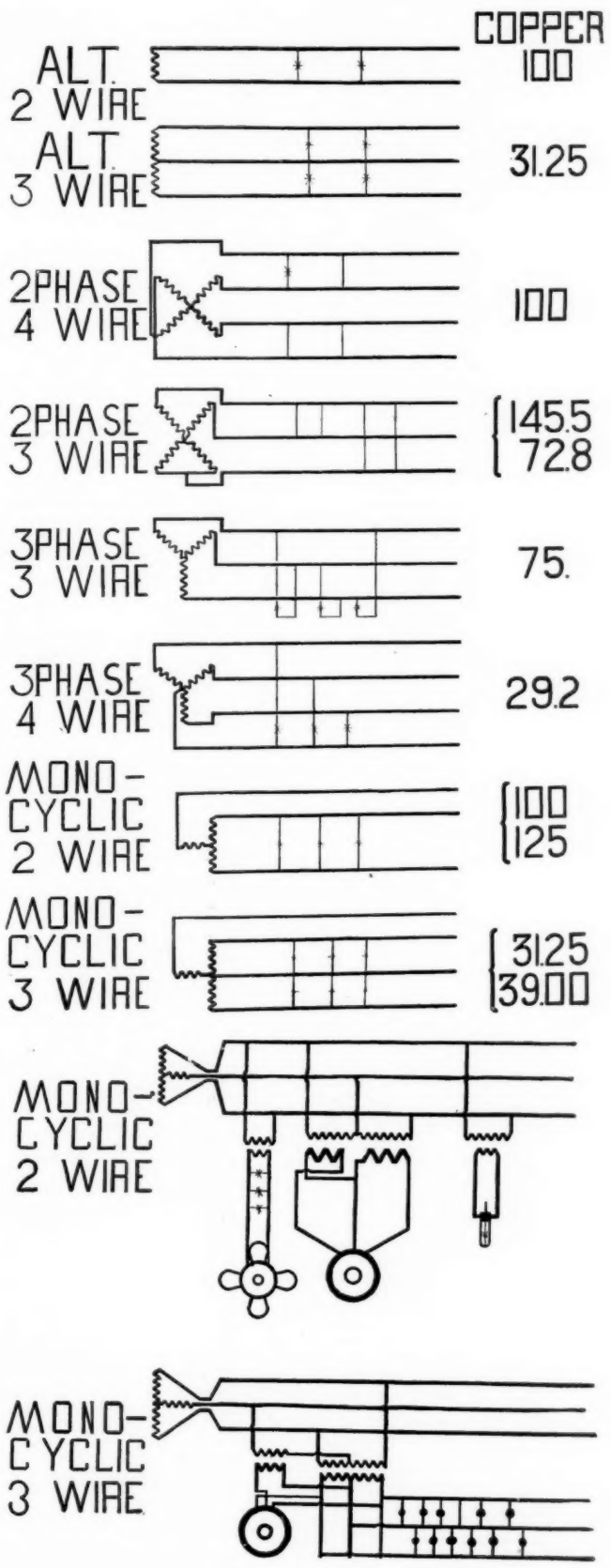
It is instructive to glance over this list of alternating lighting systems to see their relative complexity and advantages. It is especially noteworthy that any and every method of distribution that saves copper introduces in some form or other the question of balance. This is the price we pay for reduction in cost of conductors. It has not seriously interfered with the use of the Edison three-wire system; in fact, those most familiar with that system were the first to make light of the difficulty; nor do I think it stands as a valid objection to the use of the polyphase systems in cases where they are desirable, as none of them are more sensitive in the matter of balance than the Edison three-wire system which is now in such extensive and uniformly successful use. We may further note that in each of the alternating systems, where a very great saving of copper is accomplished, a fourth wire is necessary, at least if both lights and motors are to be operated, in each case, however, of trifling size.

Having now looked over the field in general, we may pass to the more minute consideration of the somewhat striking electrical peculiarities of the monocyclic system; peculiarities which, although they do not involve any particular complexity, are yet of decided interest.

The general principle of the system is well shown in this diagram So far as the main work of the generator is concerned, its winding is closely similar to that of any well-designed alternator. The armature is of the iron-clad type and the winding is made in machine wound coils, which are invariably insulated, and can be very readily slipped into place. There is, however, upon the armature a second set of coils of cross section equivalent to that of the main coil, but composed of comparatively few turns, so that the room taken up on the armature is very small, and owing to the shallowness of the slots necessary to accommodate this second or teaser coil, the output of the machine, considered as a single phase generator, is not affected. This teaser coil is located with reference to the main coil as shown in the diagram. Its place on the armature is midway between the other coils, and the electro-motive force generated is in a direction at right angles to that of the principal coil. It is evident, now, that if we connect the terminal of this teaser coil with either of the terminals of the main coil we shall get an electro-motive force compounded of the two and in some intermediate direction. In general, by varying the proportions of the two coils, and hence their electro motive forces, we could obtain a resultant electro-motive force between their terminals having any angle we pleased with either the main or the teaser coil. If, then, wires are taken upon the line from the terminals of the main coil and also from the teaser coil, we can obtain from the main line

three electro-motive forces, two of which are symmetrically situated with reference to the electro-motive force of the teaser coil, and bear to it any phase relation that we please. One of the most convenient arrangements, and that which is most generally adopted, involves such a relation of the electro-motive force of the teaser coil to that of the main coils, that we shall have on the line three electro-motive forces approximately 60 degrees apart. In other words, the resultant electro-motive forces between teasers and main coils are each 60 degrees from the electro-motive force of the teaser coil. Such an arrangement is that shown in the diagram. Under these circumstances, it is clear that, if one of these electro-motive forces were reversed, either in transformers or anywhere in the translating devices, the result would be three electro-motive forces 120 degrees apart, one of them having been turned through an angle of 180 degrees. Meanwhile the relation between the power wire, which is connected to the teaser coil, and the outside wire has no effect upon the electro-motive force between these outside wires, since the electro-motive force of the main coil itself does not interact with the power wire, except in so far as a portion of it may act with the power wire to form a resultant phase, and electro-motive force for running motors. Consequently, so far as lights are concerned, the two outside wires behave precisely like the leads from any other alternating generator, while so far as motors are concerned, we have the power of getting our three electro-motive forces 120 degrees apart, and hence have the same magnetic effect as with a three phase system. The arrangement of lights and motors with this device is clearly shown in the diagram. It is evident that we can take from the outside wires of the monocyclic system either arc or incandescent lights anywhere and to any extent the capacity of the machine permits, working for the incandescents either two or three-wire distribution at option. For a motor, two transformers are connected anywhere we please, one between the power wire and each of the outside wires. At this point the resultant phases come into play and the necessary reversal of one of the electro-motive forces is accomplished by the very simple and obvious device of reversing one of the secondaries, as shown in the diagram. To the secondary circuit thus constituted we can connect a standard induction motor, which will start and run as well as if connected to a regular three phase system, or instead of reversing one of the transformer secondaries we may accomplish the same virtual reversal of the electro-motive force by reversing one of the coils in the motor itself. We therefore have a system which, so far as lights are concerned, is a simple alternating system; so far as motors are concerned, the dynamical equivalent of a polyphase system. With a differently proportioned transformation we could place upon the secondaries two electro-motive forces 90 degrees apart, if necessary, and then run two phase motors instead of three phase motors, if there were any object in so doing. Such an arrangement, however, would be less desirable than that of the quasi three phase system, for the reason that without gaining anything in the motors we should have to generate a larger electro-motive force in the teaser coil, and hence take up more room on the armature with it, perhaps enough to have an effect upon the output of the machine considered as a single phase generator. It is sufficiently evident that the method shown would not be the only way of getting the same result. For example, in this second diagram a somewhat different arrangement is shown accomplishing precisely the same end. Here our object is to operate secondary mains on the Edison three-wire system, and in connection with them to run motors at any point we please. A large transformer to which the secondary is connected on the three-wire system is, therefore, installed, and the secondary mains distributed in any manner we please. A second and small transformer, proportioned to the total amount of motor service desired, is connected as shown in the diagram, and the power wire leading from it is taken through the whole or part of the three-wire system. The device is analogous to the arrangement of the generating coils themselves, and the result is the ability to operate a standard induction motor by connecting it anywhere on the three-wire system to the two inside wires and to the power wire. Such an arrangement as this is immensely convenient in distributing power and light in cities where, for example, it is desired to establish an extensive system of secondary mains through Edison tubes or other convenient underground distribution. It is, furthermore, interesting to know that one is not confined to the use of either two or three phase induction motors, since a monocyclic generator connected to the primary circuit makes an excellent synchronous speed without the assistance of a starting motor, in this particular being vastly superior to the pure single phase synchronous machine. But, it may be asked, how about this power wire? In case, for example, of a transmission over a considerable distance before the distributing point is reached, must the power wire be part of the transmission system? In answer, I need only call your attention to the fact that the essential point of the monocyclic system, so far as motors are concerned, is the establishing of an electro-motive force bearing the same relation to the system as is borne by the teaser coil of the generator. Consequently, in case of a tranmsission plant, the main generators at the distant station may be simple single phase machines, the subsidiary electro-motive force being furnished by a synchronous motor or similar device at any point in the system. So we might readily have an extensive transmission with a monocyclic machine in the sub-station of such size as is necessary to furnish current for what motors may be upon the system. The power wire would then run only to the sub-station. Another interesting peculiarity of the monocyclic system, and one which is not without importance in case of an extensive power distribution, is the following:

Under ordinary circumstances induction and synchronous motors are wound so that the counter electro-motive force affects the system in a perfectly symmetrical manner, and the current flows over all the wires with some degree of symmetry in response to the demands of the motors on the system. It is customary, however, in the monocyclic system to employ motors so wound as to throw a high counter electro-motive force into the power wire when the motor is at speed and loaded, thereby reducing the normal current carried over the power wire to a purely nominal amount, and this can evidently be done without sacrificing much in the matter of starting, since at the start all the counter electro-motive forces in the motors are zero. We have, then, a motor system of a type really peculiar to the monocyclic system, in that each motor will start under the same conditions of impressed electro-motive force as if it were a polyphase motor; while, when at speed and loaded, it would be operating virtually as a single phase machine. If, however, it were overloaded so that it would tend to slow down or stop, sufficient energy would flow over the power wire to bring it back to speed, just as if it were a polyphase machine. This is only one of various interesting ramifications in the system when developed to meet special conditions.



DIAGRAMS ILLUSTRATING DR. LOUIS BELL'S PAPER ON "THE MONOCYCLIC SYSTEM."

The connections shown in the diagrams, however, are those of the most direct applicability and probably which would be most extensively used for central station service. At this point it may be appropriate to ask, What is the disadvantage of such a system? It evidently secures exceedingly marked advantages in the ability to operate the lights on existing circuits or with the simplest possible kind of distribution, and at the same time to run at any point in the system synchronous or induction motors of well-tried and familiar types. The question can be readily answered; in fact, the question is almost obvious. The price which we have to pay for this advantage is the installation of the power wire, which necessarily adds something to the weight of copper in the system and to the trouble of installation. Under all ordinary circumstances the power wire needs be of trivial cross section compared to that of the other wires, since, as a rule, the energy required for operating the motors from the given central station is small compared with the total capacity of the station; and, further, it is worth remarking that the monocyclic motors, either synchronous or induction, will run perfectly well if the power wire is disconnected after the motor is at speed operating them as single phase machines. It is, of course, well-known that the single phase synchronous motor gives admirable results, and it is also true that a single phase induction motor can be constructed of excellent efficiency and other electrical properties. The only material difficulty in this case is to get the motor to start with a good torque. The monocyclic connection enables this to be accomplished. After the motor is at speed the power wire becomes no longer necessary to successful operation, so that in spite of the necessary existence of the power wire it is easy to see that the additional amount of copper is not likely to be burdensome in central station operation. It would hardly ever be necessary to install a power wire of more than one-fourth the joint cross section of the others, as given in the diagram, and generally a much smaller wire will suffice.

I have thus endeavored in a brief space to give a good working idea of the monocyclic method of combined light and power distribution which has been devised and is urged upon the public as specially adapted for the work of central station distribution on account of its unique simplicity in practice. As to what has already been done in the installation of such apparatus, a considerable number of these monocyclic generators are in daily use in central stations, for the most part operating over circuits already established and displacing the higher frequency alternators which had been previously used. They are giving excellent results, and the operation of the motors, wherever employed, has been highly satisfactory. The system, therefore, needs no extensive exploitation on paper. After once pointing out here the principal and general advantages of the system, it is better to let the plants already running speak for themselves, and let their verdict be final.

DISCUSSION.

Mr. Kelly: I suppose I can honestly begin by paying a tribute to the ingenuity of the devisers of the systems; but it is scarcely necessary, because we all know what they can do—they have already proved themselves. I cannot help feeling, however, that in this case their ingenuity has been somewhat misapplied. The most serious fault with the system is that it did not come soon enough. If it had come before the polyphase systems had been worked out, perhaps we would not have needed any polyphase system, but, coming when it does, it seems to me a step backward. In the first place, the generator, as Dr. Bell explained, is substantially a single phase generator. Now in any given generator it is not possible to get the same output and regulation when worked single phase as when worked two phase. Dr. Bell seemed

(Continued on page 124.)

LARGE ARC DYNAMOS.

READ BEFORE THE NATIONAL ELECTRIC LIGHT ASSOCIATION, CLEVELAND, FEBRUARY, 1895, BY CHARLES N. BLACK.

Glancing back over the past 15 years and noting the rapid progress made in all branches of electrical engineering, it appears strange that arc dynamos have met with so few changes, more especially so when we remember that arc lighting was one of the first branches of the science reduced to practical use on a large scale. It is impossible to ascribe this to the fact that there was nothing left to be desired in the design or the efficiency of this type of machine, since it has always been notoriously weak in respect to efficiency, and has by no means kept pace with the incandescent dynamo. Within the past 18 months, however, various manufacturers have awakened to this fact, and we have seen the results in numerous descriptions of arc dynamos appearing from time to time in the technical journals. The general tendency seems to be toward larger units and lower speeds, but, although the increase in size has, of course, increased the efficiency to some extent, we still notice the massive field magnets with their enormous amount of copper and the small armature, which alone is enough to account for the inefficiency of these dynamos. Another noteworthy fact is that, with one exception, which perhaps I need not mention, all the new machines thus far described are of what is known as the closed coil type. This is the more remarkable when we consider that fully 75 per cent of the arc lights in this country are run from open coil dynamos. The open coil dynamo at the very earliest date appealed to such men as Charles F. Brush and Elihu Thomson as being especially suited for this constant current work, and by the remarkable genius of these pioneers was so perfected that to-day machines with scarcely a single alteration from the design of 15 years ago are being sold in competition with the latest closed coil dynamos.

The question as to the reasons for this preference naturally suggests itself, but before answering it, I will briefly describe some of the most marked points of difference between the two classes of machines. As the name implies, the open coil machine has the separate coils, or sections of the windings of the armature entirely distinct one from another. In other words, they do not form a closed circuit. It will be observed in the open coil armature that each coil, or bobbin, as they are generally called, has a large number of turns, and that there are but few commutator segments; while in the closed coil armatures we have exactly the reverse; namely, few turns per coil, and a large number of commutator segments. This is due to the different manner in which they commutate. In the open coil machine a large amount of self-induction in each bobbin is by no means objectionable; in fact, one might almost say that it is essential in order to obtain the best results, while in the closed coil machine the less self-induction there is in each bobbin the better the action at the commutator. The latter is true of all closed coil machines, whether for arc or incandescent lighting, as all engineers well know who have had any experience in the designing of dynamo electrical machinery.

The first statement, however, is not nearly as well understood even among those who have had considerable experience with the open coil machine. The fact that a large amount of self-induction is advantageous in an open coil machine has never, to my knowledge, been stated before, although on it depends the successful working of a machine of 2,000 volts or more. Silvanus P. Thompson, in his "Dynamo Electric Machinery," gives a very clear account of the manner in which an open coil machine commutates.

It will be noticed that of these coils connected to the outer ring on which brushes A and A bear, only 3, 3' are in circuit, 1, 1' being entirely cut out; while on the inside ring all coils 2, 2' and 4, 4' are in circuit, the two pairs being in parallel. 4, 4' are coming into the field of best action, as Thompson calls it; in other words they are approaching that part of the field in which there is most rapid change of magnetic flux, while 2, 2' are approaching that part in which the flux is uniform. In 4, 4' there is an increasing electro-motive force being generated, and the current is rising; while in 2, 2' the electro-motive force is decreasing and the current falling. Unless 2, 2' were cut out of the circuit, a point would soon be reached where the electro-motive force in 2, 2' would be zero, and consequently 4, 4' would be short circuited through 2, 2'. Just before this occurs, however, 2, 2' have passed from under the brush, and the small current still flowing draws out the spark one sees on the commutator of all open coil machines. To one unfamiliar with this dynamo it is always a matter of wonder that this spark does not cut away the segments. As a matter of fact, it does so to a certain extent, but the current is so small, and whatever heat there is, is radiated so rapidly, that the effects in practice are almost inappreciable. At this point the self-induction of the bobbin plays an important part; were it not for this, the current in the bobbin, which is being cut out, would be reversed before the segment had reached a sufficient distance from the brush to prevent the current jumping back across the heated air space, and thus causing the machine to flash.

The design and proportioning of the field magnets are the same as in the closed coil machines. It is in the commutator and commutation then that we find the most marked difference between the open and closed coil arc dynamos, and herein lies the great superiority of the former over the latter. Take, for example, a new open coil 125-lighter and one of the latest closed coil 100-light machines. In the one there are 24 segments in the commutator, while in the other there are 160. To go into details as to which is the easiest to insulate and keep in repair is scarcely necessary before a society of practical managers and engineers.

Some advocates of the closed coil dynamo, however, claim that such a small number of commutator segments causes a discontinuity in the current, and consequently a greater strain upon the insulation of the line. This is not a new objection to the open coil dynamo and has been answered long ago. It seems, however, to have been revived recently, and I have noticed that one builder of closed coil apparatus lays great stress upon the fact that its machine generates an absolutely steady current, and, therefore, puts no undue stress upon the insulation of the line.

In 1887, Mordey, in England, made the following experiments upon a Brush machine, in order to determine how much fluctuation there really was. Six converters, each made to transform from 2,000 down to 100 volts, had all their primary and all their secondary coils joined in series. The current from the Brush machine was sent through all the low tension coils, and then, with a Cardew voltmeter, he attempted to measure the difference of potential at the terminals of the secondary or fine wire coil. The pointer, however, remained at zero, showing absolutely no electro-motive force. He then applied the wet hands across the terminals of the whole series, but with equally negative results. An experiment which I myself made not long ago confirms fully these results. The current from a closed coil dynamo, which had 72 bars in its commutator, and which, therefore, gave practically a steady current, was passed through the field coils of a 125-light arc dynamo, and the fall of potential was measured with a Weston voltmeter. The machine was then run self-exciting, and the drop through the field was again taken. The currents in both cases gave identically the same readings on the voltmeter. That there is a discontinuity in the current no one will deny, but that it is so slight that no instrument less sensitive than a telephone will show it, appears to be conclusively proven by the above experiments. This conclusion being reached, it is difficult to understand how the insulation of the conductor would be more strained by an open coil than by a closed coil machine.

A much more vital question in connection with these large units delivering current to the line at the enormous electro-motive force of 6,000 volts, or more, is this: What value will the electro-motive force attain in case the circuit is suddenly broken? From a theoretical standpoint, basing our deductions on the manner in which the two types commutate, the open coil machine has largely the advantage. Opening the circuit is the same, in one sense, as suddenly thowing a high resistance into the line; and when we do this, we shift the point of commutation back under the brush, owing to the reaction of the armature current being reduced. Consequently, the bobbin, which should not be cut until after its segment has passed from under the brush, short circuits the one in parallel with it, and as a result, the segment connected with this bobbin carries the arc around to the opposite brush, thereby causing the machine to flash; this short circuits the armature and the electro-motive force drops to zero. This flash is not due to the insulation breaking down at any point, but is simply drawing the arc of a short circuited bobbin part way round the commutator, and in this way is acting like a safety valve. The machine is not injured in any way, and

Fig. III

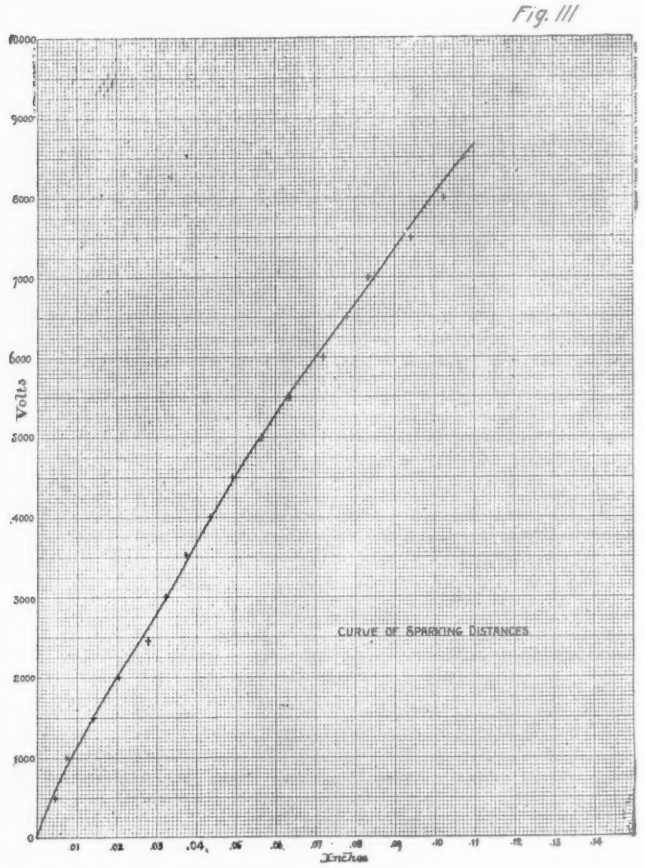


FIG. 3.—"LARGE ARC DYNAMOS"—CURVE OF SPARKING DISTANCES.

Fig. XI

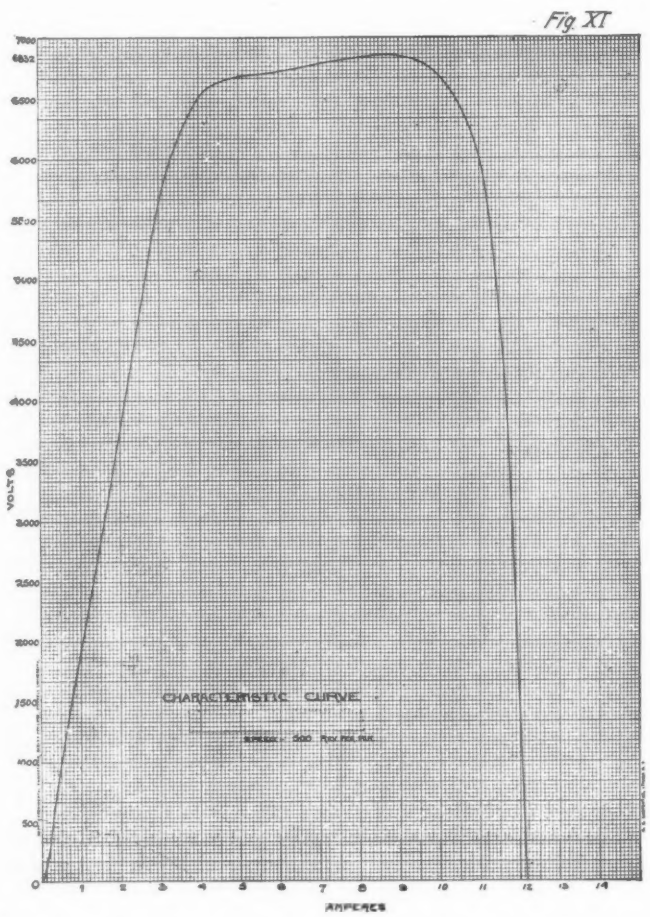


FIG. 11.—CHARACTERISTIC CURVE OF BRUSH 125-LIGHT ARC DYNAMO WITHOUT REGULATOR.

as soon as the break in the circuit is repaired it is ready to again deliver current to the line. In order to prove this by a practical demonstration and to learn accurately just what value the electro-motive force attained when the circuit was suddenly broken, we made the following experiment: The sparking distances, from 500 up to 9,000 volts, between two carbon pencils, one with a flat end and the other with a rounded one, were accurately determined within a few thousandths of an inch. The results are plotted in Fig. 3. It will be noticed that the curve is almost a straight line, and let me add, it agrees very well with that obtained by De La Rue and Muller, who made quite extensive series of experiments upon sparking distances. The terminals of the 6,250-volt machine were then connected to these carbon pencils, and the greatest distance the current would jump, on suddenly breaking the circuit, was determined. This distance corresponded to a little less than 8,000 volts, showing that the electro-motive force had risen between 1,500 to 2,000 volts. This can be accounted for by the fact that it takes an appreciable moment of time for the arc on the commutator to be carried

from one brush to the other. Owing to each segment extending about 60 degrees around the commutator, the time required to short circuit the commutator is just one-third of what it would be in the closed coil machine; consequently, I think the statement that in a closed coil machine the voltage would rise to fully double its normal value, under the same conditions, would be a very conservative one. In fact, I have many reasons for believing that it would go considerably beyond this, providing, of course, that the insulation of the commutator did not break down. If this occurred the machine necessarily would be unfit to run again until repaired. This peculiarity, if I may be allowed to call it such, of the open coil machine is especially important where underground circuits are employed, since a breakdown in the insulation, due to an abnormal rise in the voltage, is something that can only be repaired at considerable expense. Knowing that some tests on underground circuits would be of interest to central station engineers, I arranged, through the courtesy of Mr. E. A. Leslie, of the Manhattan Electric Light Company, of New York, to make some determinations as to the rise in voltage, when a long underground circuit was suddenly broken. A Brush open coil 125-light machine was connected to a 12-mile underground circuit, supplying current to 125 arc lamps. The voltmeter registered 6,850 volts at the machine terminals. The circuit was then broken a number of times with the carbon points in shunt with the break. At first the carbons were separated by a distance corresponding to 10,000 volts, and this distance was then gradually reduced until the current jumped the air space. This indicated only 5,000 volts. The carbons were then set for 6,000 volts, with the result that the current jumped twice in breaking the circuit eight times, showing that we had about reached the limit. It was then decided to try breaking the circuit near the center. Under these conditions, 5,000 volts was the highest reading we obtained, but there was a marked difference in the time of discharge. In the first case, there were two discharges in rapid succession within a half second after the break, while in the second case fully two seconds elapsed before the current jumped. In both cases there were two discharges before the arc was established, the first one being short and snappy, resembling a static spark. From this it will be seen that the capacity of the circuit more than counterbalanced any rise in voltage due to self-induction of the machine and line. With these results before us we can safely assume that the insulation of a cable will not be overstrained by any accidental break in the line. All these considerations led the company with which I have the honor to be connected to adhere to this, the open coil type of machine, in designing their large units. The general characteristics of the two machines are the same, so I will confine my description to the No. 11 or 125-lighter. This machine runs at 500 revolutions per minute, and its rated capacity is 125 50-volt 9.6 ampere arc lamps, or 66 kilowatts. It will, however, give 6,700 or 6,800 volts without undue heating. Its weight, including sub-base, pulley and regulator, is exactly five tons. The frame proper is made of the best grade of soft gray iron and is cast in three pieces. The two upper caps can be readily removed, thereby giving free access to the armature, which can be taken out and replaced in a very few minutes in case of necessity. The journals are self-oiling and self-aligning with gauge glasses, so that the amount of oil in the well can always be ascertained at a glance. The field magnet cores are hammered steel, very low in carbon and showing very high permeability. The pole shoes are steel castings, tapered at the tips to prevent excessive heating due to eddy currents. No. 8 wire is used in the field, which is two sizes larger than on the majority of arc dynamos over other makes. The current per square inch is only 746 amperes, consequently the temperature rises but little even after a 24 hours' run. The armature is of the well-known standard type, the only difference being that on account of the machine being four pole, four bobbins are connected in series instead of two.

Fig XII

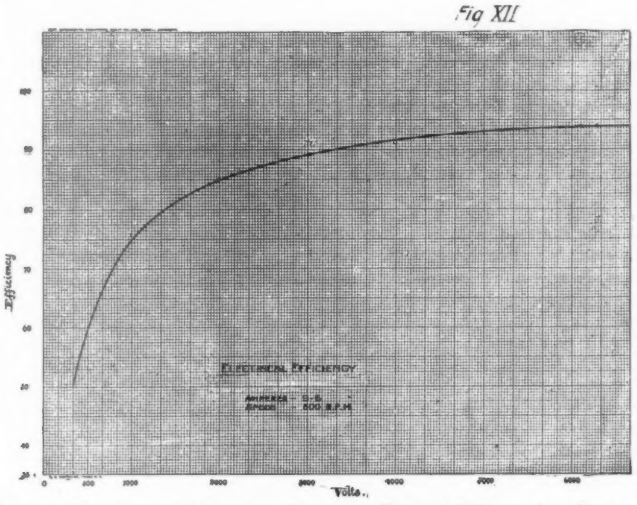


FIG. 12.—ELECTRICAL EFFICIENCY CURVE OF BRUSH 125-LIGHT ARC DYNAMO.

We now come to the commutator, that part of all continuous current dynamos which is a source, directly or indirectly, of more perplexity and trouble than all the other parts combined. Three objects were aimed at in designing the commutator for this machine. First, simplicity; second, durability; third, ease of repair. There are three distinct rings, each one of which is built up in sections of thoroughly dried apple wood filled with boiled linseed oil. Over this is forced a mica ring one-sixteenth of an inch thick, and on the sides mica disks protect the wood from the arc. Upon the mica are mounted the brass segments, and on these in turn the copper.

Lignum vitæ blocks two and three-quarter inches long serve for insulating pieces between the segments. The brushes are the tangential type, the same as those used in connection with all open coil dynamos of this design. An automatic regulator for shifting the brushes and shunting more or less of the current from the field magnets as the load varies is fastened to the front of the machine under the commutator. The small shaft which passes across the front is driven through a worm by a small belt from the armature shaft. On this shaft are mounted two magnetic clutches, which are regulated by two relays in the wall controller. The electrical energy consumed in operating the regulator is less than one-tenth of one per cent of the output of the dynamo. The machine is absolutely automatic, from one lamp to the full capacity, and the whole load may be thrown on or off with impunity.

Fig. 11 is a characteristic curve of this machine without any regulator. The readings were all taken at the sparkless position of commutation. This is remarkable from the fact that after we get over the bend the curve is almost perpendicular, and is probably the nearest approach to a constant current machine ever attained. By winding more wire on the armature we could have made this machine deliver a constant current of 9.6 amperes at all loads, without shunting any of the current from the field; but this would have increased the internal resistance and also have made the machine much less efficient at light loads. By the present method of regulation we reduce the C 2R loss at one-quarter load from 4,018 to 3,367 watts, or in other words, we gain almost one electrical horse-power. Fig. 12 is a curve of the electrical efficiency. It will be noticed that this at full load reaches 94%, which is accounted for by the liberal allowance of iron in the armature, thus reducing the reluctance of the magnetic circuit, and by the large size of the wire used on both field and armature.

Fig. 13 is a curve of the commercial efficiency. At full load this is over 90%, and approaches very closely the efficiency of incandescent dynamos of equal capacity, but the most noteworthy point is the high efficiency shown at one-quarter load.

Fig. 14 is a curve of the machine separately excited, with no current in the armature. The ordinates are the volts at the armature terminals, and the abscissæ the amperes in the field. This is really a permeability curve of the magnetic circuit. By a comparison of the voltage shown here when there are nine amperes in the field, with that of the machine when delivering current, can be seen the enormous armature reaction. The curve also indicates a new departure in arc dynamo design; namely, that the magnetic circuit is not worked at nearly as high a point of saturation as in the old types.

Fig. XIII

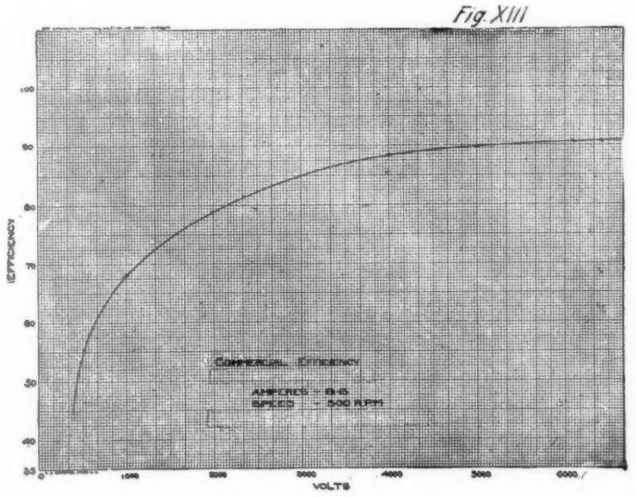


FIG. 13.—COMMERCIAL EFFICIENCY CURVE OF BRUSH 125-LIGHT ARC DYNAMO.

Fig. XIV

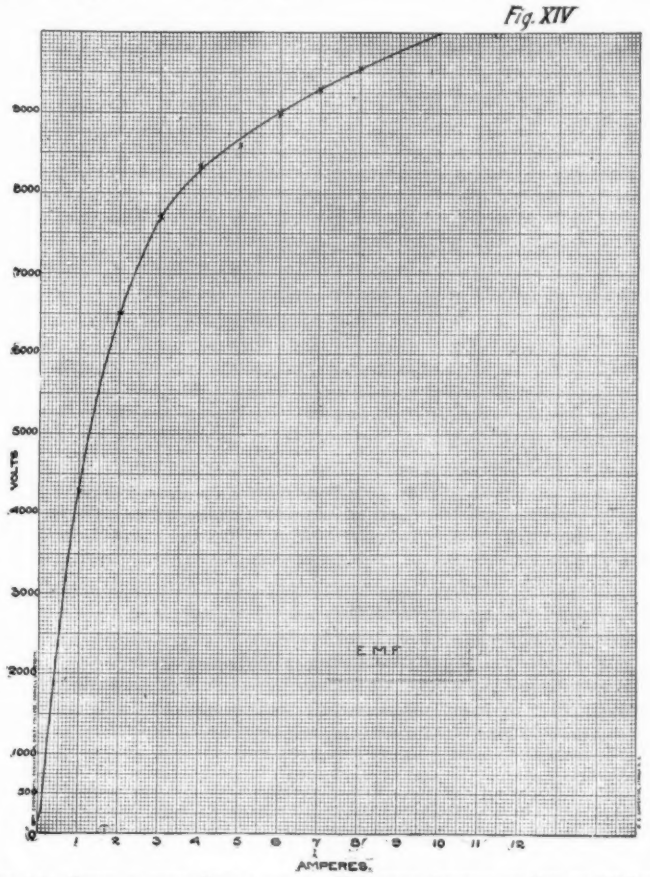


FIG. 14.—PERMEABILITY CURVE OF THE MAGNETIC CIRCUIT OF BRUSH 125-LIGHT ARC DYNAMO.

LITERARY.

A conversation with F. Marion Crawford, the novelist, recorded by Robert Bridges, assistant editor of *Scribner's Magazine* and the author of "Overhead in Arcady"—a conversation wherein Mr. Crawford tells how he came to be a novelist and how he frames and writes a novel—is published in the March number of *McClure's Magazine*. Portraits of Mr. Crawford and views of his villa at Sorrento accompany the article.

"Modern Boiler Making" is illustrated and described at length in *Cassier's Magazine* for March by William O. Webber. The author follows out the several operations which are gone through in laying out and putting together a modern steam boiler, and illustrates in profusion the several machines which are used in the work, including plate-punching, planing, flanging and shearing machines, bending rolls, steam and hydraulic riveting apparatus and many others.

In variety and significance of theme, wealth of illustration and eminence of contributors, *McClure's Magazine* for March will be found a very notable number. Mr. Gladstone furnishes an article on "The Lord's Day," wherein he shows, with his accustomed learning, by what authority and with what spiritual intention Christians keep as sabbath the first instead of the seventh day of the week, and wherein he indicates the true standard of Christian sabbath observance. Following this is a series of most interesting portraits of Mr. Gladstone, showing him at short intervals from six years of age down to the present time. Conan Doyle supplies a dramatic short story of the Franco-Prussian war, and also a short paper relating his personal experience in crossing a most difficult Alpine pass in midwinter on ski—wooden runners strapped to the feet.

THE MONOCYCLIC SYSTEM.

(Continued from page 121.)

to think that the two phase was in trouble, because of the difficulty of balancing the two circuits. I am more familiar with that system than any other, and my own reason for preferring it is because the regulation is better than if the work was thrown on one circuit. We have found that there is no more difficulty in balancing than in the common three-wire system. When it comes to the lines, I suppose it is in this point that the chief advantage of the monocyclic system is supposed to be; but the system requires at least three wires, and any polyphase system does not require more. Where lights only and not power are required, it only needs two; in practice that is all that any polyphase does. In any district, where lights only are required, you need only run a pair of wires, so that in this respect there does not seem to be any gain in the monocyclic system. The cost for copper is, at the least, according to Dr. Bell's diagram, higher than it is with the plain single phase, while the cost of copper in the two phase three-wire system is very materially reduced. In the circular distributed I see it is stated that where power only is to be transmitted by means of the monocyclic system, that the third wire is of the same section as the other two, making an addition of 50 per cent, but if the system is so working that this third wire is really a power wire conveying energy, then there is not only this additional cost, but the percentage of drop in the circuits is increased beyond that in the single phase system.

Dr. Bell has raised the question as to the periodicity at which motors can be worked. Now there are undoubtedly great advantages in low periodicity in cases of long-distance transmission; but one of them is not the possibility of operating motors. There is no difficulty in making polyphase motors of 16,000 alternations which will have high efficiency and start with large torque. As to the efficiency of the motor in the monocyclic system, there is nothing to be said against it, because the motor is substantially a polyphase motor, and whatever the polyphase motor will do, of course the monocyclic will do.

Mr. Steinmetz: I am very much honored by being able to speak before such an association as this, and may say that I have heard with very great interest Dr. Bell's interesting paper, and with much greater interest, Mr. Kelly's remarks. I can, however, not quite agree with his statement that the single phase alternating current system is antiquated and superseded by the polyphase system, and that therefore the monocyclic system is behind the times. The polyphase system has been before us now for nearly 10 years. It made its appearance shortly after the single phase system, and at a certain time after the Frankfort exhibition, when our electricians came back from Europe and talked excitedly of what they had seen. Everybody seemed to think that the single phase system would soon disappear altogether. Nevertheless, we have now thousands of single phase stations running, while the polyphase system is only just beginning to be used in special cases. Therefore, I feel confident that the polyphase system will never be able to supersede the well-known single phase system of old, but find that it possesses a limited application, although being very valuable at the proper place. The monocyclic system is entirely single phase; that is to say, the total flow of energy issuing from the generator passes through zero and is fluctuating; while the polyphase system shares with the continuous system the common feature that the flow of energy is not zero, but more or less constant. Electro-motive forces of different phases, or currents of different phases, do not constitute the polyphase system; for in the ordinary single phase system, if a reduction coil is connected in series to incandescent lamps, you get electro-motive forces displaced from each other by 90 degrees—that is, quarter-phase electro-motive force—and in a loaded transformer, and in a transformer running light, the currents are displaced in phase. In neither case, however, do we speak of a polyphase system. The polyphase system is indicated when both electro-motive force as well as currents differs in phase from each other.

With regard to the statement of Mr. Kelly, that the output of a polyphase machine is larger than that of a single phase machine, that is a common mistake repeated now for years. It means that on the polyphase armature more wire can be put than on the single phase armature. However, the output of an alternator is not limited by the amount of wire you can put on the armature, but by the armature reaction, or rather by that amount of armature reaction which you can take care of by the field; and in a single-phase machine you can, by compounding, take care of a very great armature reaction which you cannot take care of in the polyphase machine, where small armature reaction causes unbalancing of the circuit. In consequence of which the output of a polyphaser is less than that of a single-phaser of the same size and speed, or at least not greater.

Professor Thomson: The paper of Dr. Bell has been so full and so clear that it leaves very little for me to say, except that I can express my agreement with the statements of the paper, and that, furthermore, after due consideration, I think Mr. Steinmetz has the right of it. He has given an enormous amount of time and attention and close study to the question of polyphase, single-phase and other systems, and has originated a number of remarkable combinations; one of which is the monocyclic system. I think the system undoubtedly accomplishes all that has been stated by Dr. Bell to be its advantages.

Mr. Scott: I have been, and I am sure all of you have been, very much interested in the presentation which has been made by Dr. Bell of the monocyclic system. We can take it, I think, as a carrying out of the remark that was made in an association a year and a half ago, that when we have an alternating polyphase system, we have something that we can do something with. It is flexible, we can twist it about, we can make a two-phase and three-phase system, and now a monocyclic system—variations of the polyphase system, and go from one to another and get the different advantages which any one of these may present for different kinds of work.

We have had the characteristics and advantages and merits of this system pointed out. It may be well, it seems to me, to bring forward some of the questions which arise with respect to the points which have been brought out so that they may be answered now, and that we may determine the relation of this system to the other systems. To those who are not immediately and technically familiar with the subject, there is apt to be a sort of haziness about it. We hear first about the two-phase and then about the three-phase systems, as if they were entirely new and different. As a matter-of-fact there is no fundamental difference between the two. Then we have a monocyclic system. What relation does it bear to the other systems? Is it radically and entirely new? Does this euphonious name mean something which is a departure from what has gone before, or is it a modification, and, if so, of what is it a modification?

Starting with the source, the generator itself is just now somewhat in doubt. The single-phase generator is best, because it regulates better and has a better output. The polyphase generator, it is also stated, regulates well and has a good output, and, without carrying that further, we can all be satisfied by taking our choice.

We will consider a few points made with respect to the transmission circuit. There are one or two statements of Dr. Bell's which can either be called in question or certainly a little modification made of them. A two-phase four-wire system, which he has given as the third figure, he has considered as the correspondent of the alternating two-wire circuit only, and has not considered it applicable to use in a three-wire connection, in which the amount of copper is so much less. The reason of this was the added complication of running two three-wire circuits. That might be true if the area to be covered were quite small, but as central stations are usually run, the lines are carried out in different directions. In alternating stations there are anywhere from three or four to a dozen or several dozen feeding circuits running in different directions and supplying different territories. It is just as easy to divide these up into three-wire circuits for lighting, as the different parts of the city to be supplied or the districts are separated, as it would be if all of the circuits were of the same phase. If, therefore, the distribution can be carried on by the three-wire plan, the cost of copper here would be materially reduced and be made equal to that of the three-wire single-phase system. Considering the two-phase three-wire system, the figure 145.5 was stated as the relative amount of copper used, and that a possible reduction to 72.8 if the extreme electro-motive force can be increased above that for the first figure upon the diagram, which is for the two-wire single-phase system. The assumption upon which all these figures have evidently been made is that there has to be a definite electro-motive force for the carrying of lamps. If that is to be carried through the various diagrams, then the 72.8 is a proper figure. If, on the other hand, a limited voltage is the consideration to be met, we have in the ordinary three-wire circuit twice the electro-motive force of the single-phase circuit. If the same be applied to the two-phase three-wire circuits, then the amount of copper would not be 72.8, but one-half, or about 36, so that the figure 145.5 in connection with that diagram is not in accordance with the assumption of the electro-motive force being controlled by the lamps in circuit, and if the highest electro-motive force allowed is that of the three-wire circuit, then the additional figure for the weight of copper for the two-phase three-wire system should be 36 in comparison with the other figures.

Another point in connection with the lines is the unbalancing of circuits. It was stated that the two-phase three-wire circuit is one which is liable to unbalancing, because of the reaction of one circuit upon another. While this is true in certain cases, in ordinary working it is one which would be met with but seldom. The next point in the system, after going through our transmission circuits, is the transformer. The transformers for transforming a given amount of energy for lighting or for power, by the two-phase system, in which one transformer is placed on each of the two phases, is the same as that for the single-phase system. For the three-phase system, in which transformers are connected across each pair of mains, the converter capacity is the same; that is to say, if we have six transformers, we may connect them in parallel across the single-phase circuit, or we may connect them in two sets of three each on a two-phase system, or we may divide them into three groups of two each on the three-phase circuits, and each transformer will have the same individual capacity in each position. When, however, these transformers are connected as in the diagram, illustrating the monocyclic two-wire system, then, as has already been pointed out, they do not operate in their ordinary way. Although the electro-motive force upon them may be normal, the currents flowing through the transformers differ from those in the ordinary cases. They are not in phase with the electro-motive force upon the transformers, and the output of the transformers is reduced by a very appreciable amount—if I am correct in my present recollections, some 16 per cent. Thus transformers of about one-sixth greater capacity would be required for operating a motor under this system, above that which would be required if the same motor were operated by two-phase or three-phase systems.

The transformers in the monocyclic three-wire system also seem to require an excess capacity. If the large transformer in that diagram is the one which supplies the lights and operates the motor when the motor is doing something, then the little auxiliary or "teaser" transformer is one which is useful only at the start, and contributes nothing to the regular working of the motor, according to the assumptions which have been made. This transformer, therefore, is an additional piece of apparatus which must be provided in the system.

With regard to the motor itself, I observe that the motor in the monocyclic two-wire system is a three-phase motor and nothing else. I understand that the motors used are the standard three-wire motors, and the motor itself does not know where it is getting its supply; whether from a regular three-phase system or a two-wire monocyclic system. The transformers for this motor on the three-wire three-phase system would naturally be the three. We seem here to have cut off a part of this system by cutting out one of the transformers. We are not keeping the symmetrical arrangement now, but are supplying the motor by but two transformers, leading to the result to which I have just called attention; that is, a larger transformer capacity. The reversing of the secondary coil of one of the transformers, if I understand the connections and arrangement, would be obviated, and the transformer would be connected directly without this crossing if the primaries of these transformers were directly connected to three-phase mains. Suppose we have a system, then, with three-phase mains with three transformers connected, feeding respectively the three circuits of the motor. Now we cut out one of these transformers, but our motor will still run, but without the same efficient performance of the transformers. If we change the relation of the middle wire at the dynamo, or change the voltage of this wire, we can do so in such a proportion that the phases of the two primary circuits will not have their former relation, will not be 120 degrees apart, but 60 degrees apart. In this case it becomes necessary to reverse one of the secondaries in order to obtain two currents 120 degrees

apart for operating the motor. If, therefore, the "teaser" coil were wound with a different number of turns to give a higher electro-motive force, we might have a three-phase generator supplying directly three-phase mains. What this seems to be then is really the elements of the three-phase system distorted somewhat by changing the electro-motive force on the middle or "teaser" wire and reversing the secondary of one of the transformers and leaving out the third transformer. So much for the motor which operates from the two-wire monocyclic system.

The motor on the three-wire system seems to have somewhat different relations. This is not a three-phase motor, but, I take it, is a two-phase motor, and it is rather interesting.

Dr. Bell: It is a three-phase—the same motor as the other.

Mr. Scott: Very good; but on the diagrams I have seen of this monocyclic motor, I have taken it as a two-phase motor, the two windings being given in the diagram as two coils placed at right angles to one another. The very reason for bringing up this discussion and making it so full at this time is to get a correct understanding of these motors. The understanding which I got from the diagrams and explanations which I have seen of the system seem to me to represent a two-phase motor, one of the circuits being wound through directly similar to the monocyclic generator. This motor has been pointed out—I do not remember whether in the paper Dr. Bell has just read, or not—as similar to the monocyclic generator, which is stated to be a single-phase machine, wound with one winding straight through from one end to the other, with this little auxiliary or "teaser" coil connected between the middle of that coil and a third terminal. If this be the case, then it seems to me that this motor is either a single-phase motor or a two-phase motor. The explanation given of the operation of this motor has not been very complete to-day. If I make a mistake in drawing on other sources of information in regard to it, I hope I will be corrected.

This motor I have taken to be a single-phase motor when running at speed, but essentially a two-phase motor, which is supplied by the three wires which are operated by two transformers which have electro-motive forces at right angles, or the 90-degree relation of the two-phase motor. We are supplying, then, to this motor the output of two converters which are operated at a difference of 90 degrees. All the circuits of the motor are active while the motor is coming up to speed. One of the windings on the motor is somewhat different from that of the windings on the transformer; it is not exactly proportioned in both of its circuits to the electro-motive force supplied, so that when run at speed one of the circuits does all the work. It is very much as if two transformers are connected in parallel, one giving 100 volts and the other 99 volts. If we put a load on the two transformers connected in multiple until the electro-motive force drops to 99 volts, then one of the transformers would be carrying all the load and the other nothing. The motor described here is the same motor, if I understand it correctly, as is described in the patents granted to Mr. Steinmetz. Then it seems to me that this motor is very similar to a sort of lop-sided two-phase motor, stronger on one side than the other. The two circuits operate with fair effect to bring the machine up to speed and then one of the circuits takes all the load and the other has but little to do. The motor in running at full speed and doing its regular work operates as a single-phase motor. A single-phase induction motor will not carry the same load that the two-phase induction motor will. Anyone who has operated two-phase induction motors knows that one circuit may be cut out and the machine will continue to run, but it will not carry the same load as before. If that be true, and the information upon which I understand the connection of this motor be true, then this monocyclic motor seems to be a rather decrepit two-phase motor.

There is one point to which attention was called by my able friend Mr. Steinmetz to which I take exception; that is, his definition of a polyphase system or a polyphase motor. He was pleased to say that difference of phase in electro-motive force, with no difference in current, does not constitute a polyphase system, and he pointed out that if a coil and a lamp be placed in series the electro-motive force measured directly across the lamp and the electro-motive force measured directly across the coil would not be in phase with one another, but would occur at different times. So, also, if a coil and a lamp be placed in multiple so that the same electro-motive force is on the terminals of both, then the currents are not of the same phase. But he held that neither of these would constitute a polyphase system, because the flow of energy was not constant. A constant flow of energy may be taken as a definition of a polyphase system, so might difference of electro-motive force or difference of currents. As I understand a polyphase system, I do not mean that the electro-motive force at one part of the circuit may be one thing, and at another part somewhere else another thing, either at a great distance or connected with a different piece of apparatus, would not necessarily constitute a multiphase system; but if the two different elements with difference of phase cause the operation of that apparatus, then we have the essence of a polyphase system. If we have a motor and wind its circuits in such a way that the circuits shall differ in capacity or self-induction, if the currents in the different circuits differ in phase, and owing to this the apparatus operates and the motor runs, then we have something which should be legitimately considered as polyphase apparatus. We have an apparatus which operates, due to the difference of phases or to too many phases, and in the polyphase motors that is the characteristic element. The element which causes rotation, the fundamental element, seems to be the shifting of the magnetic field in the apparatus. It is not fundamentally essential to the operation of such an apparatus that the currents give equal energy to the apparatus at all times, but that they be supplied in such a way as to give the shifting field, which will cause the rotation and running of the apparatus. I would, therefore, call a multiphase machine one which has in it a shifting magnetic field of many phases, or currents producing these magnetic fields, rather than one having constant flow of energy to the apparatus.

The power wire operating in the monocyclic three-wire system is said to be a powerless wire. This wire is for the purpose of operating the motor while it is coming up to speed. The two great problems in an alternating current motor are: first, the bringing of the motor up to speed; and secondly, keeping it there. These are two different problems, and different methods are devised for effecting the two different results; and very often the elements which contribute to one detract from the effectiveness of the other. The power wire, if I am right in understanding this motor, does not necessarily supply power to the motor at the time when the motor is running at full speed, but it contributes to the power which is required for bringing the motor up to speed, and would continue to deliver power to the motor instead of lying idle and resulting in so much idle copper in our system, if the motor were a complete and symmetrical motor instead of one which has possibly been made defective to meet the requirements of this system.

Dr. Bell: The first question raised may be granted, that the monocyclic system is a modification of something. Is it now to be considered as a single-phase or two-phase system, or a polyphase system of some sort? I think that question was clearly answered by Mr. Steinmetz when he pointed out that you must consider as a polyphase system one in which the energy remains constant—the common characteristic of all polyphase systems, whether evenly balanced or unbalanced. In the monocyclic system we have three currents substantially in phase with each other, and the total energy passes through zero. I fail to see how the widest possible extension of the definition of a polyphase machine could be made fairly to include it. The most that could be said would be that there might be a limiting case in which the unbalancing of a polyphase system might go on until the total energy would actually pass through zero. If that is so, it might serve equally well as a limiting case for either the single-phase or the polyphase system. It is certain that the monocyclic in its operation suggests a polyphase system. In the character of the currents which flow through it, and in the distribution of the energy, it is peculiarly single-phase in its character. I was interested in Mr. Scott's remarks on the subject of the four-wire connection of the two-phase system. Now, with a four-wire connection, it is, of course, possible to use the Edison three-wire system on each branch if one so desires; but in order to do so and to run motors at the same time one must interlink the two three-wire systems; in other words, you must have two three-wire systems, each system being approximately balanced as to itself, and each three-wire system balanced as respects the other three-wire system occupying the same territory. They must be interlinked for motor service, and that is the reason which, I maintain, bars out the two-phase four-wire system from employing the Edison three-wire connection, just as it must bar out in the same way, and even more effectively, the three-phase system from operating on each of its three phases an Edison three-wire system. It makes a complication of circuits for general distribution which would be perfectly intolerable, two three-wire circuits in the same territory, and each balanced with respect to the other—it would be something better imagined than described. In certain cases, for lights only, it may be applied, because you are at liberty to scatter your circuits, but even then it would require more or less balancing of the two systems, else you get into trouble with one side of the machine having a greater load than the other, which causes a difference in drop which cannot be compensated by compounding. With the two-phase three-wire system, Mr. Scott's point was well taken on the question of maximum voltage. However, if you are dealing with the maximum permissible on the transmission line, where the thing to be considered is not the maximum on the distributing system to translating devices, but the maximum permissible on the whole system, and if you confine yourself to that, you will find that combining the two-phase into three wires requires excessive copper. If you confine yourself to the secondary system alone it will be possible to permit the same maximum voltage as on the straight Edison three-wire, and I should say that the same rule would apply to the reduction of copper in the three-phase three-wire system, or any other systems, in varying degree, according to their character.

As regards the question of unbalancing, I think I stated with a fair degree of distinctness that, with any polyphase system, though unbalancing may occur, and occur in a serious degree, I do not believe it would be a common occurrence. I think I specifically included the polyphase systems in general.

With regard to the question of the reduced capacity of transformers operating on three-phase or monocyclic systems: As a matter of fact, there are three plans of working, we will say, with a three-phase system as regards its transformers. In the first place, we may have a composite transformer, including all three legs of the circuits, which has been used with very fair results. Next, we may use three transformers, or, finally, only two transformers. Sometimes it is more convenient to use three and sometimes two. We must remember that there are not to be had an infinite number of sizes of transformers, nor an infinite number of sizes of motors. The consequence is it is sometimes a difficult matter to find transformers which will exactly fit a given horse-power of motor, and the loss of capacity which is thus met in furnishing transformers too large for the motors (because we must be sure to have them large enough) may easily amount to 10 or 15 per cent either with two or three phases, and unless special transformers are made to fit the motors, we are liable thus to require an increased total capacity of transformers as well on two-phase as on three-phase systems. With the three-transformer connection for the three-phase circuit we have one very material advantage which perhaps makes it worth while to employ it in many cases, and that is, if one of the transformers for any reason is crippled, we can operate at least two-thirds of the output with the remaining two, whereas on the two-phase system, if one transformer gives out the motor is crippled, either by overloading and stopping absolutely, or able to run at half output as a single-phase motor, but in no case starting until the transformer is fixed. If two transformers are used, the statement has been made that the loss in output in connecting three-phase transformers is about 16 per cent. I would like to see experimental evidence brought up in this case. We have been informed in many well-written technical articles that the output of the polyphase machine was thus and so in connection with a single-phase machine, and we know that the facts do not fully bear out the theory. We are now given similar information in regard to the transformers. While I am not prepared to dispute the fact without having experimented on it, I would like to see some evidence that the difference in output rises to any practical magnitude.

As regards the teaser transformer, I think we may consider the secondary transformer on the monocyclic three-wire system as practically part of the power wire. It needs to be of small size and furnishes only a small amount of energy. With that connection the one transformer furnishes the power wire for the whole three-wire system. It is not a part of each

motor, simply a part of a power wire, and as such it may be taken as a part of the installation belonging to the three-wire system. The single small transformer in the system furnishes the entire power wire for the whole system.

As regards the motor on the monocyclic two-wire system, it is correct in a sense to say that the motor does not know whether it is on a three-phase circuit or a monocyclic. As regards its operation, it does not know—that is as regards the directions of the electro-motive forces in it. It is a matter of perfect indifference which system it is on; but as regards the character of the currents and their direction, if the motor possessed an ammeter to put in its own coils, it would find there was a very large difference in the distribution of currents. As regards its magnetic qualities it would not matter, although the actual distribution of the current is widely changed. We have in the monocyclic induction motor, a motor which in its operative three-phase motor. There is a possibility and sometimes a great convenience in being able to work a monocyclic generator as a synchronous motor. Used in such a way, it works during its operation like any other synchronous motor. It is a possibility which is sometimes very convenient; the motor starts itself, and the teaser coil, when the motor is up to speed, produces no effect on the rest of the system if the motor is properly designed with reference to suppressing the electro-motive force of the teaser circuit. In the monocyclic three-wire system we have in the first place a three-phase motor structure but operating on a monocyclic three-wire and teaser circuit, with the properties and distribution of currents — or electrical character — of the single-phase system. The actual details of operation in a monocyclic motor are somewhat complicated. Substantially, we have a structure which in all its characteristics is only proper to be operated on the monocyclic or three-phase

REPORT OF THE COMMITTEE ON DATA.

PRESENTED TO THE NATIONAL ELECTRIC LIGHT ASSOCIATION, CLEVELAND, FEBRUARY 21, 1895.

The information contained in the tabulated report submitted herewith, while recording data from fewer places than usual, is believed to contain correct information and more than usual detail. Certain classes of equipment are not reported in sufficient numbers to warrant correct averages, but every central station manager will find in the table a style of equipment sufficiently like his own to enable him to compare results with at least a few others who are similarly equipped. The table contains reports from 24 stations using coal as fuel. The highest economy is shown in report No. 22, where 262 watts are generated from one pound of coal, the plant furnishing nearly 23,000,000 watts during 24 hours, the equipment being triple expansion engines with dynamo on the engine shaft, and horizontal water tube boilers with heaters, without economizers, the firing being done by hand. This result is secured from one-half each soft coal and hard screenings. An examination of this report proves it to be a high average for 24 hours, as with an evaporation of 9.37 pounds of water per pound of combustible, and a water consumption of 17 pounds per horse-power, allowing 10 per cent non-combustible in the coal, and taking the efficiency of the generators as stated at 85 per cent, we have $\frac{9.37 \times .90}{17} \times 746 \times .85 = 314$ watts produced from one pound of coal. The average is much nearer the theoretical efficiency of a modern steam plant than any report previously received by this committee.

Taking an average of the 10 reports from stations generating over 5,000,000 watts in 24 hours, we have 147.5 watts per pound of coal, or a production of one electrical horse-power for four pounds of coal on a basis of the efficiency of the generating machinery as stated in the last report by this committee.

Previous reports by this committee have been criticised as inaccurate and incomplete, and an attempt has been made in the work here submitted to improve it in both these particulars. From the first, the results of this work have been handicapped by reports from the central stations incorrect, incomplete and based upon a variety of testing instruments constructed without any absolutely uniform standard. And again, many central station managers do not wish to have their work made public, and in order to get at the results secured by these people, the information has previously been furnished to the committee through your secretary, in such a manner that the committee were relieved of the responsibility of the exact source of the information furnished. This, in a measure, defeats the main object of the work, as is shown by a letter to this committee from H. T. Edgar, of the Georgia Electric Light Company, in which he says: "Suppose that you, for instance, in Baltimore are accomplishing very good results, it certainly is to the advantage of every electric manager in the country to know this and to get detailed information from you. The information published by the committee neglects to state where the data is received; consequently, while we may know that there are certain companies accomplishing the best of results, we do not know which

TABULATED REPORT OF DATA RECEIVED FOR THE NATIONAL ELECTRIC LIGHT ASSOCIATION.

	EQUIPMENT.					PRODUCTION.														FUEL.			
	ENGINES		BOILERS		DYNAMOS.	ARC CIRCUIT					INCANDESCENT.				POWER.								
NO OF REPORT	CLASS.	WATER CONSUMPTION PER H.P.	CLASS	EVAPORATION FROM AND AT 212° COMBUSTIBLE		EFFICIENCY	AVERAGE AMPERES	AVERAGE VOLTAGE.	HOURS RUN	TOTAL WATTS	AVERAGE AMPERES	AVERAGE VOLTAGE.	HOURS RUN.	TOTAL WATTS.	AVERAGE AMPERES	AVERAGE VOLTAGE	HOURS RUN	TOTAL WATTS	READINGS EVERY MIN.	TOTAL WATTS FROM ALL CIRCUITS	WHOLE AMOUNT OF COAL USED IN ONE DAY.	WATTS PRODUCED PER LB. OF COAL.	KIND AND GRADE OF FUEL.
22	A	17	A	9.37	Multipolar	85					7670	124.9	24	22,967,952					30	22,967,952	87,358	262	½ Soft Coal, ½ Hard Screenings
1	B & F		C & D		Con. & Bipol.		10	8145	24	1,954,800	224	1140	24	6,128,640	50	500	13	325,000	60	8,408,440	46,700	180	Hocking Screenings.
9	B		C		Multi.,Alt.,&c.		10	2387	13	5,896,081			24	2,434,500		500		2,322,750		10,653,331	59,884	177	Run of Mines, Alabama.
15	F		C		Arc, Alt.		6.8	47	4	1,278	66.4	1010	15	67,064						997,238	5,460	182	Georges Creek, Cumberland.
8	E	27¼	C		Alt. & Con.		10	1000	12	120,000	37	1100	13	529,100					15	649,100	3,700	175	Cumberland.
18	B X F X	32.7	C	11.3	Alt & Con.		6.7	7000	8	355,144	7.05	1172	24	1,983,024	42.4 80.3 65.2	1142 325 548.2	23¼ 10 16½	1,125,765 260,170 589,743	15	4,313,846	24,750	174	Pennsylvania Soft Coal.
12	B		B	8.4	Arc.		9.5	48	14	10,552,752										10,552,752	62,000	170	Soft Coal.
2	B E Z	15.5	A		Various		9½	4800	12	6,600,000	150	2200	24	7,920,000		250 525	24 18	908,200 460,000	10	15,878,250	50 tons.	158	Slack and Nut.
16	E		C		Arc, Alt.		by	Meter		246,000				580,000				948,000		1,774,000		150	Pocahontas, Soft.
13	C X	24	C	10.5	Various.		6.8	2275	14	7,042,426										7,042,426	50,238	140	Babylon Pea.
10	B F	23.6	B	11.34	Alt., Bipolar.		9.8	50	12	1,817,256	137	1130	24	3,715,200	36	535	24	465,000	30	5,997,456	45,000	133	Illinois Washed Pea.
21	C X		A C		Alt., Bipolar		6.8			1,779,051	37		16½	837,930			10½	190,000	30	2,806,981	21,203	132	George's Creek, Cumberland.
17	B E		C		Alt., Bipolar.		6.8		7	357,000	40	1200	14	672,080					60	1,029,000	8,000	128.6	Coaldale, Bituminous.
19	F		C		Alt.		6.8	1100	5⅜	43,010	27	1100	7½	Meter. 224,400					60	267,410	2,200	121	Pocahontas, Cumberland.
3	A Y	18	C	8.8	Alt., Bipolar		10	Meter	24	1,990,000		Meter	24	90,900			24	950,000		3,849,000	35,322	108	Michigan Run of Mines, Poor.
20	F		C	9.02	Various.		6.8	6500	8½	367,333	100	240	16	384,000						845,333	8,131	104	Cumberland and Hard Scr'ngs.
14	A				Various.						6000	116	24						15	16,704,000	164,000	100	Buckwheat, No. 1 and 2.
4			A		Various.		10	3472	24	833,250	339	117.5	24	3,823,600	23	1060	24	584,640	15	5,241,500	60,283	86	Illinois Lump and Nut.
7	F		C	7.68	Alt.		6.8	1150	7¼	56,840	24	1040	7¼	105,560					30	162,400	1,963	83	Second Youg'y, Nut.
6	F		C		Alt.		6.8	656¼	8	35,700	16.75	2000	8	268,000	5	3916	6.5	127,269	30	530,996	6,583	80	Indiana Slack.
5	G X		A		Con. & Mult.						180	1166	24	2,016,000						2,016,000	25,600	78	Illinois Nut.
11							10	50		1,500,000	104 140	120 1100	24 24	3,700,000 299,000	32	550	14	509,850		6,008,850	86,750	69	Soft Slack.
23	B E X		A								160	1000	16	1,640,000					30	1,640,000	42,000	44	Indiana Block.
24	F		C	6.3	Various.		10	50 ca.	12	1,104,250	112	1120	12	1,505,280	45	223.5	18	181,035	30	2,790,565	79,800 11,900	30	Bituminous Pea. Bituminous Slack.

EQUIPMENT.

CLASS A. Boiler Room: Horizontal Water-tube boilers, feed through heaters by steam or power pump; hand firing. Engine Room: Triple Expansion Condensing Engines. Dynamo on Engine Shaft.

CLASS B. Boilers Vertical Water-tube, economizers, feed as A. Hand firing. Engines, Corliss Compound Condensing, belted to jack shaft.

CLASS C. Boilers, Horizontal Tubular, feed as A. Engines, Simple Corliss or slow speed, condensing, belted to jack.

CLASS D. Boilers, Upright Tubular, feed as A. Engines, Simple Corliss, Non condensing.

CLASS E. Engine, High Speed Compound Condensing, belted direct.

CLASS F. Engines High Speed Simple Non-condensing, belted direct.

CLASS G. Engines, High speed Compound Non-condensing.

REF. X. Any of the above non condensing.

REF. Y. Belted to dynamo.

REF. Z. Dynamo on the Engine shaft.

qualities is like a polyphase motor. Nevertheless, the distribution of currents in it, although resulting in a perfectly symmetrical production of motive power, is something that you cannot find in any polyphase motor. It depends on the particular action used in the monocyclic system. It has essentially a single-phase current, although its effect as regards magnetism is closely similar to that of the true polyphase motor.

As regards the motor on the monocyclic three-wire system, I was much pleased with the ingenuity with which Mr. Scott constructed a large, able-bodied and well-dressed man of straw for the purpose of knocking the gentleman down and jumping on him with both feet. The motor is not a two-phase motor of any kind. It is an ordinary induction motor, such as is used indifferently on three-phase or monocyclic systems. Doubtless, from the experience of the speaker, he deeply realized how bad a bad two-phase motor could be. The winding of the monocyclic motor is in every respect similar to that of the circuits. The currents which flow through it, however, are not three-phase currents, the electro-motive forces being, however, 120 degrees apart. The currents are substantially in phase, but the magnetism produced is so distributed as to give a perfectly symmetrical torque on the motor, just as though it were run upon a polyphase circuit; a point which I think justifies me in the remark I made at the beginning, that the monocyclic system is to be regarded not altogether as a modified and glorified single-phase, nor again as a decrepit and disreputable polyphase system, but rather as in a class by itself.

"The Universal Electrical Directory (J. A. Berly's) for 1895" has been received from the publishers, H. Alabaster, Gatehouse & Company, London. This is the fourteenth year of publication of this valuable reference book, and the present is the best issue of all. A thumb index makes reference to the various sections easy.

they are and do not know the conditions under which they are operated. I think that a great mistake has been made in the electric light business, that the managers of the different companies are so anxious to keep the information to themselves. I am willing to put myself on record as saying that the books and accounts, and all the information possible to obtain about the Georgia Electric Company is at the disposal of every central station manager in this country. If I have been fortunate enough to operate this company at a high economy and accomplish good results, I am perfectly willing that every electric company should know it and know how it was done. If I have been unfortunate enough not to accomplish good results, I should like to be in communication with the parties who have been more fortunate than myself, so that I might obtain from them the necessary information to operate my plant as they operate theirs. I cannot see the slightest advantage in keeping this information secret. There is certainly not one central station manager out of 10 who is ashamed of what he is doing, and if he accomplishes good results he ought to be proud of it. I compared the results of our plant with the results of the various plants contained in the data sent out, and I find that we compare very favorably with the best. There are, however, quite a number who are doing better than we are, and I should like to know very much who they are, what their conditions are and how they do it. It seems to me that the more information electric men can get with reference to their business the better, and my understanding is that the National Electric Light Association was formed for just this very purpose. There is another point, and that is that this business, like the gas business, is one in which the company has to deal with the public, and the public is always ready to criticise a corporation. If we can convince the public that we are not charging extortionate prices, but simply making a reasonable profit, they will be a great deal better satisfied and feel more kindly towards us than if they have the idea that our prices are high and our profits very large."

A careful review of this work for the past three years reassures this committee that the present method of securing data from central stations by individual effort on the part of the committeemen, with the understanding that the information is to be held confidential, meets all the requirements, as any manager can communicate with the author of any report, either through the committee or the secretary of this association, and reports can be had in this way from many who are not as willing to have their work made public as is our friend from Atlanta. Several members of the present committee were unable to give the matter attention, and the table is, therefore, made from a limited number of reports. If the succeeding committee could pledge its membership to secure at least 25 reports each from the central station managers in their locality, a much more valuable report can be made. We submit what has been done, trusting that it may prove useful, and that it may be elaborated and improved if found of sufficient value to central station managers to warrant their more complete and careful co-operation.

H. M. SWETLAND, New York.
C. R. HUNTLEY, Buffalo, N. Y.
E. F. PECK, Brooklyn, N. Y.
G. H. BLAXTER, Pittsburgh, Pa.
E. W. ROLLINS, Denver, Colo.
W. A. WHITTLESEY, Pittsfield, Mass.
E. L. POWERS, Chicago, Ill.
J. A. VAN ETTEN, Little Rock, Ark.
H. W. SEXTON, Anniston, Ala.
Committee.

TELEPHONE NEWS AND COMMENT.

Robert Eddy, of Danville, Ky., will put in a telephone exchange at Lebanon.

R. L. Andrews and Richard Schney will organize a $25,000 telephone company at New Britain, Conn.

Messrs. E. S. Bray, T. B. Kitchens and Fred. Hoffman have organized a company to operate a telephone exchange in Paragould, Ark.

By a recent order of the War Department telegraphy is to be taught to the officers of the Austro-Hungarian cavalry, commissioned and non-commissioned.

The output of the American Bell Telephone Company for the month ending February 20 was as follows:

	1894-5	1893-4	Increase.
Gross output	11,198	5,280	5,918
Returned	7,534	6,560	974
Net output	3,664	ret.1,280	4,944
Since December 20:			
Gross output	18,829	9,733	9,096
Returned	13,479	13,248	231
Net output	5,350	ret.3,515	8,865

The Mutual Telephone Company, lately organized at Fort Scott, Kas., to compete with the Bell company, went into actual operation last week. The new company is using the Reynolds transmitter and subscribers are only charged $1 a month, while the Bell company charges $4 a month.

The Anderson, Ind., City Council has granted franchises to both the Harrison and American telephone companies. The Harrison company signalized this by immediately cutting the Bell rate one-half, and the American made a still greater reduction. The Bell company serves notice that it will meet all reductions.

W. H. McCollough, auditor of the Great Southern Telegraph and Telephone Company, is in Natchez, Miss., investigating the feasibility of constructing a telephone line between Natchez and St. Joseph, La. If the line is built it will give the entire front of the fifth Louisiana levee district telephonic communication, which would be of inestimable advantage in flood season.

An interesting experiment is being tried in London in the use of the telephone. The Lord Chief Justice has given permission for the placing of a transmitter in the Royal Courts of Justice in such a position as to catch every sound within the apartment. It is proposed in this way to enable solicitors and others interested in cases tried in the court to listen to what is going on while at a distance. The test is at present confined to the Lord Chief Justice's own court, but if it proves successful telephones will shortly be introduced into other courts for the same purpose.

Isaac H. Herts and Benjamin H. Herts, of New York City, have obtained from Judge Andrews of the Supreme Court a temporary injunction restraining the Metropolitan Telephone and Telegraph Company from removing the telephone instruments in their place of business at 896 Broadway and their factory at 104 to 110 East 32d street, and also from discontinuing or in any way interfering with the telephone service which they have been having. The suit is of a similar nature to that recently brought by Lawyer Simon Sterne against the same company for a similar purpose, it being charged that the company was insisting upon charging exorbitant rates for its services.

General Seldin E. Marvin has been chosen president of the Hudson River Telephone Company, President Joseph P. Davis, of Boston, resigning on account of a pressure of other business. He will continue as a director of the company. As it was thought desirable that the new president should serve upon the executive committee of the board, Colonel David B. Parker, of Buffalo, resigned his place upon the committee and General Marvin was substituted. Colonel Parker will also continue as a director of the company. The directors agreed to establish a news exchange at Rhinebeck to connect with the Poughkeepsie exchange.

The new building of the Rocky Mountain Bell Telephone Company, at Salt Lake City, Utah, was the scene of a brilliant gathering of the friends of the president and officers during the evening of February 16. The building and plant were carefully looked over, and the intricacies of the system fully explained by Superintendent Murray. On the second floor President George Y. Wallace received his guests, and the offices of the secretary were transformed into a punch and tea room. Beside the interest shown in the system and the beauty of the building, the guests enjoyed themselves in exactly the same manner as at an ordinary reception. A large number were present, and the affair lasted until 11 P. M.

Hello! M. & B., Hello!

AGENTS WANTED

IN UNOCCUPIED TERRITORY FOR THE ONLY ABSOLUTELY NON-INFRINGING

TELEPHONE.

ADDRESS:
M. & B. TELEPHONE CO.,
Bullitt Building, Phila., Pa.

PROPOSALS INVITED.

WATER WORKS, CUTHBERT, GA.—Board of Water and Electric Light Commissioners, City of Cuthbert, are inviting sealed proposals for complete system water works, March 19, specifications being furnished by the Mayor upon application. Plans can be seen in Mayor's office in Cuthbert, or engineer's office, Mable & Sullivan, Gould building, Atlanta, Ga.

ELECTRIC LIGHTS, CUTHBERT, GA.—Requests are being made by several firms and individuals of the Mayor and Council of Cuthbert for a franchise and contract to put in an electric light plant of both arc and incandescent lights. Council have deferred active operations in putting in the plant, although $10,000 in bonds have been favorably voted, pending propositions on the franchise plan. If it can be made to interest of city to adopt this, they will do so, otherwise later on in the year they will put in their own plant and operate it.

R. L. MOYE, Mayor.
Cuthbert, Ga., March 1, 1895.

THE MUTUAL TELEPHONE COMPANY, of Corsicana, Texas, solicits lowest cash delivered prices on from 100 to 150 battery telephones for immediate delivery with all necessary adjuncts for installing same.

They must be guaranteed first-class in make and for service, and against infringement, and such as will operate in perfect harmony with the 100 "National" instruments already installed.

SEALED PROPOSALS

Will be received at the City Clerk's office, city of Menasha, Wis., until four o'clock P. M., March 5, 1895, for furnishing, operating and maintaining fifty (50) arc, twelve hundred (1,200) candle-power electric street lamps on the streets of said city, with the privilege of as many more lights as the City Council may elect, provided the total number does not exceed sixty-five (65) at the same price per light, for a term of five (5) years. An exclusive franchise will also be granted for all arc and incandescent lighting for both commercial and domestic use for a term of five years. For specifications, etc., apply to

W. W. REED,
City Engineer.

FACTS. Electrically-driven machinery is modern and proper. Crocker-Wheeler apparatus is the best for this purpose, liberally proportioned, a generous factor of safety, and no trouble, if you allow us to advise you.

Crocker-Wheeler Electric Co.
Manufacturers and Electrical Engineers.

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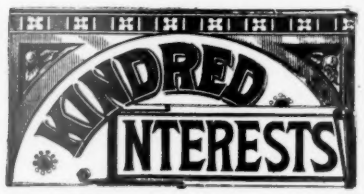

The New Catalogue of Electric Railway Material of the Central Electric Company, of Chicago, will be sent on application. Every railway man should get one of these handsome and complete books.

The F. E. Belden Mica Mining Company, of Boston, have established a branch office in New York city at 182 Franklin street, in charge of Mr. Union Adams, Jr. All the company's products may be found at the New York office.

The Metropolitan Electric Company, of Chicago, are introducing to the trade a new carbon battery of high efficiency test for open circuit work. The battery is guaranteed and offered to the trade seeking a high-class article of this description.

The Geo. L. Colgate Company, 136 Liberty street, New York city, announce some very attractive bargains in "Northern Light" 16 candle-power incandescent lamps in barrel lots. These lamps are guaranteed for 800 hours average life, and the prices asked for them are extremely low.

The Metropolitan Electric Company, Chicago, are sending out circulars advising the trade that they carry in stock the celebrated Hoffman rod polish. This company have found that the Knapp-Sellner adjustable desk lamp holder is attracting considerable attention. It is found to be just what is required for desk light.

The Brush Electric Company, Cleveland, O., has issued two unusually handsome and well illustrated pamphlets entitled "Seventeen Years' Use of Brush Arc Apparatus" and "Arc Lighting Extraordinary — Formula: One Square Foot Floor Space = One 2,000 Candle-Power Arc Light." Both pamphlets may be had free on request.

The Dynamo Electric Maintenance Company, of Boston, has opened branch offices in New York city at 97 William street, and in Hoboken, N. J., in the Second National Bank Building. Treasurer Dinsmore, of the home office, has been in New York for several days arranging these matters. The company is already doing a large business.

The Sperry Electric Railway Company, of Cleveland, O., recently received the following letter:

THE CHICAGO GENERAL RAILWAY COMPANY,
CHICAGO, ILL., January 17, 1895.

MR. L. H. ROGERS, General Manager Sperry Electric Railway Company, Cleveland, O.

DEAR SIR—Your electric brake, which is attached to our new cars with new style Sperry controller, is creating a "furore" in the electric railway world in Chicago. There isn't a day but what I have men connected with the electric railways here to examine your brake. I had a representative of the St. Paul and Minneapolis Street Railway Company here yesterday, and he was very anxious to learn what the cost of the brake would be and also how he could replace some of their old Sprague No. 6 motors with Sperry whaleback and electric brake.

I predict for the Sperry company a very bright future. Wishing you every success, I remain,

Yours very truly,
(Signed) W. B. BRENNAN, Superintendent.

Elliott Brothers, 101 and 102 St. Martin's Lane, London, W. C., England, have issued their new catalogue for 1895, No. E. 4. It is unusually complete and well edited. Almost every conceivable measuring device of delicacy and refinement, for electrical and other purposes, is enumerated. Mr. Keith Elphinstone is now in the United States in the interests of Elliott Brothers. He intends to establish a new agency here for the sale of Elliott Brothers high-class instruments.

The Walker Manufacturing Company.—This company, with its general offices in Cleveland, O., points to the following excellent showing of business, a result of one year's work in the electrical field. These are only some of the larger orders:

The Complete Electric Construction Company, New York city, two 50 kilowatt belted lighting generators.

The Rahway Electric Railway Company, Rahway, N. J., one 100 kilowatt belted multipolar generator; three double car equipments, 25 horse-power spring mounted steel motors.

The Philadelphia Construction Company, Philadelphia, Pa., for the Schuylkill Electric Railway Company, Pottsville, Pa., three 400 kilowatt belted generators and switchboard apparatus; two double car equipments, 25 horse-power motors.

The Michigan Electric Company, Detroit, Mich., for Saginaw Consolidated Street Railway Company, Saginaw, Mich., one 200 kilowatt belted generator; six complete car equipments, 25 horse-power motors.

Hartford and West Hartford Street Railroad Company, Hartford, Conn., two double car equipments, 50 horse-power steel motors; two double car equipments, 25 horse-power steel motors.

C. E. Loss & Company, Chicago, Ill., for Waukesha Street Railway Company, Waukesha, Wis., one 150 kilowatt belted generator; three double car equipments, 50 horse-power steel motors.

The Detroit Railway, Detroit, Mich., two 400 kilowatt direct coupled generators; one 750 kilowatt direct coupled generator.

Gloucester, Essex and Beverly Street Railway Company, Gloucester, Mass., two 225 kilowatt direct coupled generators.

The Worcester Construction Company, Worcester, Mass., for the Gloucester, Essex and Beverly Street Railway Company, 16 double car equipments, 25 horse-power steel motors.

Jasper County Electric Railroad Company, Carthage, Mo., two 200 kilowatt belted generators; five double car equipments, 30 horse-power steel motors.

Besides the above they have taken orders for their spring mounted steel motors for the Louisville Railroad Company, Louisville, Ky.; Atlantic Avenue Railway Company, Brooklyn; Ottumwa Electric Railway Company, Ottumwa, Iowa; Aurora Street Railway Company, Aurora, Ill.; Bloomington City Railway Company, Bloomington, Ill.; Steinway Railway Company, Brooklyn; Kansas City Railway Company, Kansas City; Atlanta Electric Railway Company, Atlanta, and many others. They have also taken large orders for their general work, among which might be mentioned contract for four 2,000 ton hydraulic cotton compresses for Mr. W. W. Bierce, Montgomery, Ala.

STEAM ENGINEERING

(Stationary, Locomotive or Marine); Mechanics; Mechanical Drawing; Electricity; Architecture; Architectural Drawing and Designing; Masonry; Carpentry and Joinery; Ornamental and Structural Iron Work; Railroad Engineering; Bridge Engineering; Municipal Engineering; Plumbing and Heating; Coal and Metal Mining; Prospecting, and the English Branches. Students make rapid progress in learning to Draw and Letter. The Steam Engineering course is intended to qualify engineers to secure Licenses. Send for Free Circular, stating the subject you wish to study, to

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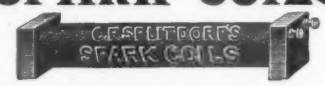

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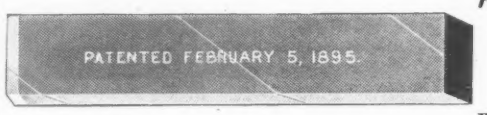

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G. M. ANGIER & CO., 64 Federal Street, Boston, Mass., New England.
S. N. BLAKE, Elmira, N. Y., Northern and Western New York.
THE WILL & FINCK CO., 818 Market Street, San Francisco, Agent for Pacific Coast.

The Consolidated Electric Storage Co.,
44 Broad Street, New York.

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